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In assessing technology one can identify key developments of the past that have substantially contributed to an advance in the state-of-the-art of a technology. Often, some of thse advances come from totally unrelated fields. The shock and vibration measurement process is certainly a good example. Comparing our present measurement capability with that of 30 years ago, I can identify four developments of the past, inside and outside of this technology, that were significant because they materially advanced our overall shock and vibration measurement capability. I would like to briefly mention these.

One of the first developments occurred at the National Bureau of Standards during the mid-to-late 1950's. It was the development of the Reciprocity Method for determining the absolute sensitivity of primary standards for shock and vibration measurements. This led to a primary standard for accurately calibrating shock or vibration measuring instruments, and it also enabled reliable shock and vibration measurements to be made over a broad frequency range.

The developments of the piezoelectric accelerometer, and later the piezoresistive accelerometer, also resulted in advances in our measurement capability. These instruments enabled shock and vibration measurements to be made over a wide frequency range on a variety of items ranging from small electromechanical devices to large structures. Prior to the commercial availability of these accelerometers, our capability for making shock and vibration measurements was limited by the low useful frequency range and by the large size and the high mass of the available instruments.

The Fast Fourier Transform is one example of an advance in an unrelated field that substantially helped to enhance our shock and vibration measurement capability. It initially enabled frequency spectra calculations to be made on main frame digital computers rapidly and more economically than could previously be made with the use of the conventional Fourier transform algorithm. Typical early uses included processing large volumes of random vibration test data, and controlling shock tests on electrodynamic shakers. It also led to other advanced measurement capabilities to be mentioned later.

Developments in the technologies of solid state electronic devices and in the microelectronic devices, although totally unrelated to the field of shock and vibration, have also contributed to advances in our shock and vibration measurement capability. Initially, they led to more compact instruments for signal conditioning, recording data, and analyzing data; but, continuing advances in the microelectronics technology, combined with the Fast Fourier Transform algorithm, have resulted in sophisticated digital equipment to make the necessary measurements for controlling many types of shock and vibration tests or analyzing data.

I have identified four highly significant developments of the past that have collectively, rather than individually, enhanced our shock and vibration measurement capability. This enhancement has greatly contributed to the state-of-the-art of shock and vibration technology.

R.H.V.

EDITORS RATTLE SPACE

THE APPLICATION OF THEORY TO PRACTICE -- AN ENGINEERING CHALLENGE

The ultimate test of a new technology is its successful application to the development of techniques or hardware. Theory has been applied to practical experience ever since science and technology developed and motivations existed to use them to solve practical problems. The application of theory usually involves as much ingenuity and work as development of the theory itself.

Although tools such as the computer have somewhat simplified the process of generating nomographs and charts, comprehension, motivation, and vision are also necessary. A thorough understanding of both theory and application are required if theory is to be adopted to the solution of practical problems. Motivation and vision are part of the process of knowing what problems are important and need to be solved.

The adaptation of new technology to the solution of practical problems usually begins with a strong motivation to solve a difficult problem. The engineer realizes that the potential for solution exists, and he knows that the information must be distilled from theory (perhaps published as a technical journal) and simplified to meet the situation. After the problem has been solved, the engineer will perhaps seek to generalize the results and publish them in a design magazine or as a case history. In any event publication of the material involves individuals who might also use the results and further expand on them. It is possible that the adaptation will be republished several times in different forms until it is eventually incorporated into a textbook, handbook, or monograph. Use by many persons tests the credibility and usefulness of an application.

This process of adapting rigorous complex theory to engineering is one of the great challenges of engineering today. Many engineers face this task daily, but too often the value of the results is underestimated and they wind up buried in confidential company reports. One of the great accomplishments of NASA has been their technology transfer program. NASA engineers and their contractors have published technical reports, surveys, and notes that have been specifically directed to the application of theory. These publications have been a successful outlet for the adaptation of theory to practice.

It is hoped that more engineers in industry and governmental agencies will be able to benefit from programs similar to the one established by NASA. The adaptation process is challenging and time consuming but it does advance technology and thus contributes to society.

R.L.E.

NONLINEAR/TRANSIENT ROTOR DYNAMICS ANALYSIS

M.L. Adams*

Abstract. This review article presents an update of work since 1980. Because this topic -- nonlinear/transient rotor dynamics -- is a specialty within the specialty of rotor dynamics, the number of investigators concentrating on it is not large. However, the significance of recent work to various types of rotating machinery is high.

It was stated in a previous review [1] that, although linear analyses are adequate, simpler, and therefore preferred in most routine rotor vibration analyses, they provide predictions that are in considerable error -- both qualitatively and quantitatively – in some specialized but important situations. The most important nonlinearities arise at the journal bearings and other close-running rotor-stator clearances when vibration amplitudes become large and approach full clearances. Among the situations of practical importance are large mass unbalance events such as blade loss on steam turbines and gas turbine jet engines. For a more evolutionary review of early work and computational techniques, the reader is referred to the previous review article [1]. In this review, recent work and important results are briefly highlighted.

LARGE SYSTEMS

A general purpose computer code (TETRA) was developed [2] under NASA sponsorship for the analysis of transient and nonlinear conditions in multi-spool shaft gas-turbine jet engines. TETRA is now available from NASA upon request. This code, developed primarily to study blade loss events in jet engines, includes several options that make possible the study of complete engine structures. TETRA includes, for example, various nonlinear stiffness effects as well as rub/impact contact between rotating and stationary components. An option to include flexible disks is unique. The basic computational approach is based on that shown by Adams [3]; time-step integration of the motion of one or more rotors is performed in the free-free modal space of each rotor, and the connection forces (i.e., bearings, rubs) are treated as forces external to the free-free rotor (s).

In a currently ongoing NASA-sponsored grant [4], the TETRA program is being retrofitted with an additional nonlinear element to handle squeeze-film dampers. This damper element was originally developed on an earlier NASA grant and has been detailed by Adams, Padovan, and Fertis [5, 6]. Figure 1 shows a comparison between computational predictions using TETRA and test results on the E^3 energy efficient engine developed for NASA.

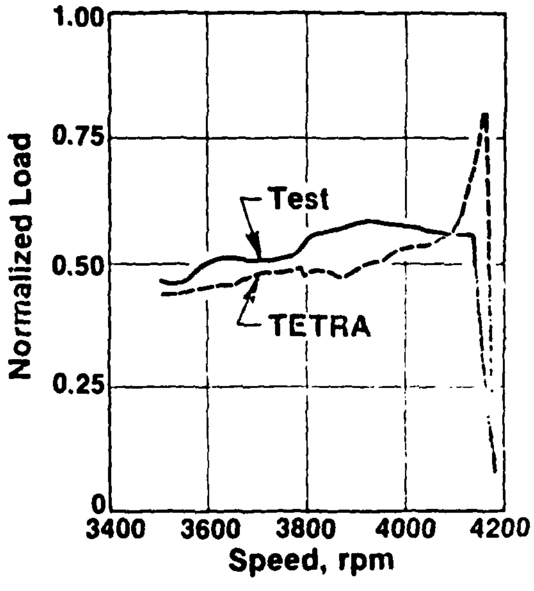

Figure 1. Results computed with the TETRA code compared with measurements on a blade-out test (courtesy of General Electric Co.)

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Nelson and Meacham [7, 8] have also developed a code for transient rotor vibration of large rotor-bearing systems. They also used a modal approach; however, they performed the time-step integration of rotor motion in the constrained-rotor modal space, as opposed to the free-free rotor modal space approach discussed above. Pons [9], on the other hand, used the free-free rotor modal approach to study large power plant machinery vibration, especially steam turbines with large unbalance.

Adams [10] has summarized the potential dangers from large amplitude subharmonic resonance induced by journal bearing dynamic nonlinearities in steam turbine/generator units having a large rotor unbalance. That article contains photographs of two such catastrophically failed 600 Megawatt turbine/generator units.

Adams [11] has reported on a recently completed computational investigation on large unbalance vibration of a steam turbine. Extensive parametric studies showed the effect of unbalance magnitude as well as other important variables. Shown in Figure 2 is the single most important set of results. They reveal a phenomenon that is probably *typical of all* units that operate only marginally below instability threshold speed -- and several such modern large turbine/generator units are presently *in operation* in the electric utility industry. That phenomenon is the tendency for a sudden drastic increase in subharmonic vibration levels for unbalance magnitudes above some critical level (approximately 25,000 lbs for the case shown). This jump phenomenon could not occur without inherent nonlinearities. The results also confirm, in greater depth, earlier results that show the considerable superiority of tilting-pad journal bearings in controlling such potentially catastrophic vibrations. The motivation for Pons [9] work at Electricite De France was also in response to a recognized need stemming from a 1977 *massive failure of a large (600 MW) turbine/generator* unit near Paris.

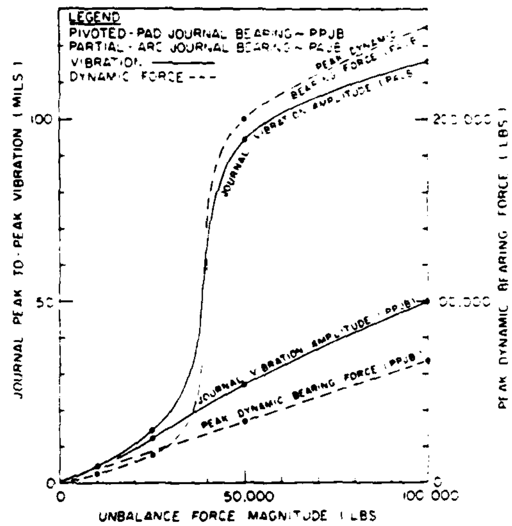

Figure 2. Steady-state response of a low-pressure steam turbine as a function of unbalance force magnitude, at 3600 RPM. Two sets of results are shown: one in which the rotor is supported by two standard partial-arc journal bearings, and the other by two pivoted-pad journal bearings [11]

BASIC STUDIES

Simple models and experimental results have been used [12] to show that mildly nonlinear effects present with moderate unbalance levels are sufficient to raise the instability threshold speed above that found with almost perfectly balanced rotors. The practical importance of this work is that improved rebalancing of a marginally stable machine can actually lead to much higher vibration levels if the reduction in unbalance level is sufficient to reduce the actual instability threshold speed below the running speed. Childs [13] used a simple Jeffcott rotor model to demonstrate the excitation of subharmonic vibration arising from nonlinear radial stiffness associated with rotor-stator rubbing over a portion of the rotor's orbit.

Kascak [14, 15] used a direct integration formulation to study the transient nonlinear dynamic response of gas turbine engines subjected to rotor-stator rubbing induced by large rotor unbalance. For co-rotational rotor whirling the rotor is positively damped by the rubbing. For counter-rotational whirling the rub force puts energy into the rotor vibration; i.e., negative damping. The computational simulations given by Kascak show that, if the rotor-stator rubbing is sufficiently forceful, it can impose a counter-rotational whirling vibration on the rotor that leads to uncontrolled large-amplitude vibration.

Such a phenomenon is known to have caused actual engine failures -- the apparent motivation for Kascak's work at NASA.

In companion papers Mays and Davies [16, 17] reported on their investigations of the vibrational consequences of propagating transverse rotor cracks. They performed both analyses and experiments to study this very important problem. Their several general conclusions are apparently most applicable to large turbine/generator units. This work was conducted at the Central Electric Generating Board in England.

Mitchell and David [18] indicated that, in geared rotor systems, the usually neglected nonlinear coupling effects between torsional and lateral vibrations are potentially as large as the linear effects of the decoupled system. They proposed a simple equivalent system based on a spring-supported damped pendulum because it contains the type of nonlinear terms found in dynamically-coupled nonlinear rotor equations. Their numerical simulations indicate reasonable accuracy with the simple equivalent system.

Adams and Payandeh [19] used a time-transient nonlinear dynamic analysis to study the motion of statically unloaded journal-bearing tilting pads. Their major finding is that unloaded pads can exhibit a strong sub-synchronous self-excited vibration. The frequency of this periodic motion is somewhat below half the rotational speed and bears a close relationship to self-excited vibration of rotors on lightly loaded non-tilting pad journal bearings. The identification of this type of *self-excited pad-flutter vibration* has practical significance to the solution of problems involving damage to unloaded pads; such problems are particularly common on large steam turbines. A comprehensive parametric study showed the bearing parameters that are important in eliminating self-excited pad vibration.

Ritchie [20] discussed the basic problem of computationally fast and reasonably accurate approximate solutions of the Reynolds lubrication equation. The motivation is, of course, continuing interest in the prediction of nonlinear response of rotor-bearing systems; such predictions typically require thousands of solutions of the bearing film pressure distribution for even simple problems. Ritchie revitalized the approach he first introduced some years earlier. His approach is based on a Galerkin's method first-order improvement to the classical short-bearing approximation.

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LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains an article about linear dynamics of cables and chains.

Dr. M.S. Triantafyllou of the Department of Ocean Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts has written a review of cable dynamics. A historical background is followed by sections containing literature reviews of the formulation of the problem and of linear dynamics.

LINEAR DYNAMICS OF CABLES AND CHAINS

M.S. Triantafyllou*

Abstract. This paper is a review of cable dynamics. A historical background is followed by sections containing literature reviews of the formulation of the problem and of linear dynamics. Effects of elasticity on the linear dynamics of an elastic cable hanging between two points at the same level are stressed.

The linear dynamics of a taut string provided the first partial differential equation ever to be studied and solved, and significant early developments in mathematics are associated with linear cable dynamics. Interest in the subject has not ceased, and significant results have been obtained in recent years.

At first glance, the dynamics of cables seem deceptively simple. It is true that very powerful numerical techniques exist today that could solve the most complicated cable problem, linear or nonlinear. But understanding the most fundamental properties of cables has been achieved, even to the present day, only through analytic solutions; numerical techniques have been used only to repeat analytical findings, at least for linear dynamics. On the other hand, numerical solutions remove assumptions often necessary to obtain analytic solutions, thus providing results of general applicability.

HISTORICAL BACKGROUND

The taut wire was the first cable to attract attention because it was used for musical instruments. Pythagoras in the 6th century B.C. and Aristotle in the 3rd century B.C. knew qualitatively the relation between frequency, tension, and length of a taut cord. Galileo in 1638 and the monk Mersenne in 1636 published qualitative results based on experimental measurements. Hooke and Sauveur published similar results, as well as the first observations of nodes. Taylor, in 1713, published the first dynamic solution of transverse cable dynamics by assuming a response shape. Daniel Bernoulli published theories of oscillation of hanging chains in 1738 and, in 1755, his superposition principle of several harmonics, derived for the taut string. This principle remained controversial until Fourier, in 1822, illustrated such superpositions. D'Alembert was the first to derive the partial differential equation of small transverse dynamics of a taut wire; Lagrange solved the problem. Euler derived the equation of a hanging chain and then obtained a series solution for the first three natural frequencies. Poisson derived, in 1820, the governing equation of a cable element subject to a general force and used it to derive the final solution to the problem of a hanging chain.

In 1851 Rohrs used approximate techniques to solve the problem of a uniform, inextensible chain hanging between two points at the same level. Routh, in 1868, solved the same problem for a chain the static configuration of which is a cycloid; he reduced his solution for small sag-to-span ratios to recover Rohrs' results. In both problems the chain was considered inelastic; not surprisingly, in the limit of zero sag the results did not reduce to the taut wire results.

A number of investigators considered elasticity effects [3, 32, 36]. It was in 1974 [15] that in-depth understanding was presented of the effects of elasticity on the dynamics of an elastic cable hanging between two points at the same level.

LITERATURE REVIEW OF PROBLEM FORMULATION

Consistent problem formulations for cable dynamics date to Poisson in 1820. Subsequently, every author offered improvements and generalizations to include, for example, the motion of a cable in a liquid. Good accounts of problem formulation before 1970 are

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available [7, 8]. Derivations of the dynamic equations in Cartesian coordinates have been published [18, 31], as has a derivation in local tangential and normal coordinates [9, 13, 37].

There is no ambiguity about the dynamic terms, but some differences exist in the fluid-related terms. This article focuses on linear dynamics, so that linear (or linearized) terms are the most important. The usual simplification is followed in that the fluid term is decomposed into an added mass and a (linearized) damping term. Some authors go out of their way to protest against even the use of such terms, but the process can be thought of as a decomposition along the (perpendicular) vectors of velocity and acceleration. The thorny issue is the choice of the added mass and damping coefficients that, because they are frequency dependent, angle dependent, Reynolds number dependent, or even time dependent, make such a decomposition indeed useless. From an experimental point of view, the measurements of Ramberg and Griffin in 1977 [25] are valuable in providing such coefficients.

From a theoretical point of view effort is concentrated on the added mass term. Lighthill [21] derived an expression for the sectional added mass of a cylinder the static configuration of which is a straight line and is towed along its axis. Neglecting viscous effects, he proved that, if a dynamic motion occurs with wavelength-to-diameter ratio larger than 5, a strip theory approach can be used; i.e., the added mass force depends only on the local acceleration. If the two-dimensional added mass coefficient of a cylinder with the same cross section as the local cylinder section is denoted as A(x), U is the velocity of tow and q(x, t) is the local transverse displacement. The added mass force is

$$\left(\frac{\partial}{\partial t} - U\frac{\partial}{\partial x}\right)\left\{A(x)\left(\frac{\partial}{\partial t} - U\frac{\partial}{\partial x}\right)q(x,t)\right\} \quad (1)$$

This approach was extended for cables inclined in a current [6]. The same assumptions of inviscid flow and large wavelength-to-diameter ratio were used to justify a strip theory approach. The result, however, does not reduce to Lighthill's result for zero inclination angle because it contains one material and one simple derivative instead of the double material derivative of equation (1) and therefore should be corrected accordingly. Expressions for the same problem including elasticity effects have been derived [2, 5].

Separation phenomena, neglected in the formulations above, have far more important effects than the effects considered [1]. The exception is a horizontal cable, where, for linear motions, the thickness of the boundary layer is the only viscous related effect. Until conclusive experimental results are obtained, therefore, no formulation seems superior, and the simple use of an added mass term in the form

$$A(x)\,\frac{\partial^2 q}{\partial t^2}(x,t)$$

can be considered equally acceptable.

The remaining point is that this force acts along the instantaneous (dynamic) position of the normal vector, so it provides no contribution in the tangential direction, unlike the cable mass term. In any event, such contributions are of second order and, therefore, have no effect on the linear problem.

A linearized fluid damping coefficient has been derived theoretically [20, 22, 23]. However, the choice of appropriate C_D coefficients and comparisons with experimental results [19, 25] have not yet been done systematically.

LITERATURE REVIEW ON LINEAR DYNAMICS

The taut string, the first cable to be studied, is an idealization of a cable the static configuration of which is a straight line; the static tension is constant. It can oscillate transversely and longitudinally (elastic waves), and the two modes are decoupled. A significant point concerns the effect of the elastic stiffness on the transverse modes. Quantitatively, the stiffness has no effect, but it must be finite; otherwise, transverse oscillations are geometrically impossible. If T_o is the static tension, ρ_c the cable density, A the cable sectional area, L the span, and E Young's modulus, the natural frequencies in the transverse direction are given as

$$\frac{\omega_n}{\frac{1}{L}\sqrt{\frac{T_o}{\rho_c A}}} = n\pi \qquad n = 1, 2, 3\ldots \quad (2)$$

and in the longitudinal direction as

$$\frac{\omega_m}{\frac{1}{L}\sqrt{\frac{E}{\rho_c}}} = m\pi \qquad m = 1, 2, 3. . . \tag{3}$$

The value of To/A expresses the longitudinal stress in the cable, which is much lower than E; otherwise, the cable will break. As a result, the first elastic natural frequency corresponds to a much higher (typically the 10th to 20th) transverse natural frequency. This means that, for the first few natural frequencies, stretching can be considered to be quasi-static.

Also, the non-dimensional value of the frequencies squared, as seen by equations (2) and (3) is of the order $n^2\pi^2$; i.e., high. Both observations have been used to derive asymptotic or approximate solutions.

A freely hanging (under its own weight) chain also has a static configuration that is a straight line; but the tension varies linearly and becomes zero at the bottom point. As a result, the solution in the transverse direction is expressible in terms of Bessel functions instead of the sinusoids of the taut string. The solution for the elastic waves is identical with that of the taut string, as are the elastic natural frequencies. The first transverse natural frequency is close to that of a pendulum having the same mass and length. The first few transverse natural frequencies are

n	1	2	3	4	5
$\omega_n \sqrt{\frac{L}{g}}$	1.203	2.760	4.327	5.896	7.466

where g is the gravity acceleration.

Rohrs in 1851 [28] and Routh in 1868 [29] considered the in-plane -- i.e., in the plane of the static solution -- transverse dynamics of an inelastic chain of span ℓ and sag d hanging between two points at the same level. Because of the curvature of the cable an element can move in two dimensions without stretching when the two motions are coupled. The men found that, for small sag-to-span ratios, the antisymmetric transverse modes -- i.e., antisymmetric with respect to a vertical plane perpendicular to the static configuration at the midpoint -- are identical with those of a taut wire; the natural frequencies of the symmetric modes are the roots of the equation:

$$\tan\left(\frac{K_n \ell}{2}\right) = \frac{K_n \ell}{2} \tag{4}$$

$$K_n = \omega_n \Big/ \sqrt{H/\rho_c A} \tag{5}$$

H is the horizontal component of the tension at the ends. The first few symmetric modes are

n	1	2	3	4
$\omega_n \ell \Big/ \sqrt{H/\rho_c A}$	2.86π	4.92π	6.94π	8.95π

The corresponding values for a taut wire are 1π, 3π, 5π, . . . indicating that the first symmetric mode is missing for the inelastic chain. This is indeed the case because it is geometrically impossible for an inelastic (i.e., unstretchable) chain to oscillate in the mode indicated (see Figure 1).

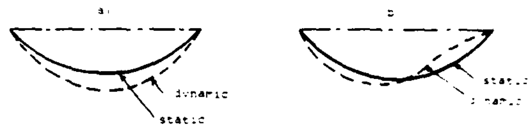

Figure 1. Mode (a) is impossible for an elastic chain because it involves stretching, so mode (b) is the first inelastic chain mode

Within the same frame of inelastic chain dynamics, the next major development was an ingenious asymptotic solution to the same problem of Rohrs and Routh but for deep sag [31]. Equations were derived for coupled axial and transverse dynamics, the directions axial and transverse are defined relative to the static configuration, so they vary along the cable length. Time variation was assumed sinusoidal, and the governing equations were reduced to a single fourth order differential equation in the space variable; the equation was solved asymptotically.

Basically, the argument of large non-dimensional frequency and slow spatial variation of the axial vibration were used. These derivations had been first used in a different form by Routh in 1868 [29] and then repeated by practically every author in one form or another; Saxon and Cahn [31] did it in a consistent manner, and their solutions were in good agreement with experimental results and semi-empirical formulas published in 1949 [24].

The same solution was derived using a different asymptotic technique [12]. The analysis of shallow

sag cables was extended for multi-span cables in 1941 [27].

The out-of-plane motion of a cable with a two-dimensional static configuration is uncoupled to first order from the in-plane motions. Its solution in the case of small sag is given by the taut wire solution and, in the case of deep sag, by a relatively simple asymptotic or numerical solution.

Power solutions have been derived for the in-plane modes of a hanging inelastic chain for sag-to-span ratio up to 0.76 [35]. The technique has been extended to out-of-plane motions and depth-to-span ratios up to 1.09 [10]. The two supports were allowed to be at different levels.

The assumption of an inelastic but perfectly flexible chain is valid for large sag-to-span ratios and for materials with high elastic stiffness. For small sag-to-span ratios the inelastic solutions reproduce the solutions of Rohrs [28] and Routh [29], which cannot reduce to the taut wire results. For this reason several authors considered the effects of elasticity [3, 33, 34, 36] and derived the most general linear equations of cable motion.

Irvine and Caughey [15] derived an approximate solution for the in-plane dynamics of an elastic chain hanging between two points at the same level and investigated the effect of elasticity systematically. Their assumption was that stretching is quasi-static and that the sag-to-span ratio is small, so that the dynamic tension is almost constant throughout the cable length and varies only with time. For a straight line it would be constant; sag introduces a catenary-related variation that is small for small sag-to-span ratios. They found that the antisymmetric modes are given by the taut wire solution and that natural frequencies of the symmetric modes are the roots of the equation

$$\tan\left(\frac{K_n \ell}{2}\right) - \frac{K_n \ell}{2} - \frac{4}{\lambda^2}\left(\frac{K_n \ell}{2}\right)^3 = 0 \quad (6)$$

$$K_n = \omega_n / \sqrt{H/\rho_c A} \quad (7)$$

$$\lambda^2 = \left(\frac{\rho_c A g}{H}\right)^2 / (H/EA) \quad (8)$$

The quantity λ^2 is proportional to the elastic stiffness and is the most crucial parameter. For infinite elastic stiffness, λ^2 is infinite and equation (6) reduces to equation (4) of Rohr and Routh; for zero elastic stiffness taut wire results are obtained. For intermediate values of λ^2, the first symmetric natural frequency can be anywhere between 1π and 2.86π (Figure 2). Thus, it can coincide with the first antisymmetric natural frequency, which is independent of λ^2 and equal to the taut wire of 2π. The point of intersection of the two lines was called mode crossover because it corresponds to a change in mode shape from a two-node mode to a four-node mode (Figure 3). This change occurs at $\lambda^2 = 4\pi^2$ and is repeated for all symmetric modes at values of $\lambda = 2n\pi$. Irvine and Caughey [15] also restated the fact that the out-of-plane modes are given by the taut wire results.

Equation (6) was first derived for a parabolic, small sag cable using a different methodology and nomenclature [32]. A graph solution was provided, but the solution was never explored.

The confirmation of these developments by experiments led several authors to work within the frame

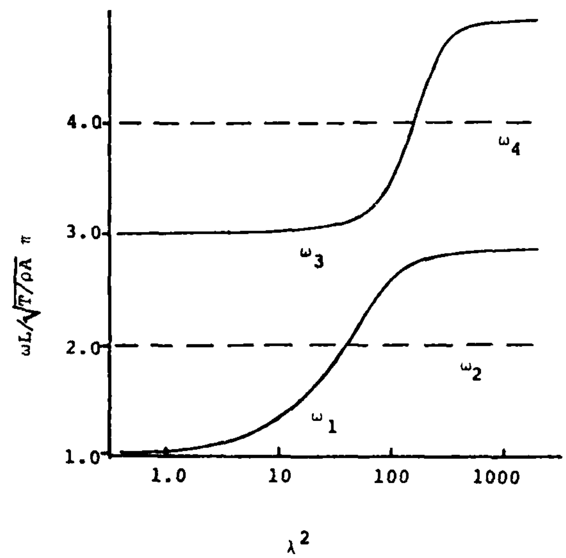

Figure 2. The first four natural frequencies of a horizontal elastic cable of small sag-to-span ratio

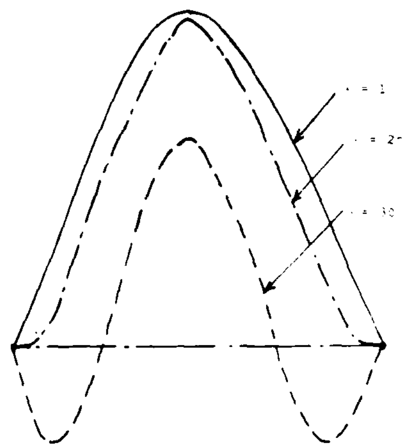

Figure 3. The first symmetric mode of a horizontal, small sag elastic cable for various values of λ (λ = 2π corresponds to crossover)

set by Irvine and Caughey [15]. The results were extended for forced response and applied to earthquake problems [16]; however, the assumption of quasi-static stretching limits its applicability.

In 1975 the equations of motion of a cable were derived and linearized [42]. Numerical solutions were obtained by representing the cable as an aggregate of discrete structural elements joined by frictionless pins. Crossover results and large sag results were confirmed, and parametric studies were done.

The finite element method [14] has been used to solve the equations for small and large sag-to-span ratios and for inclined cables; i.e., ends at different levels. Too few elements were used however, and the result was a small overprediction of the symmetric natural frequencies above crossover. Mode crossover was confirmed, and one more parameter was introduced to account for the angle of inclination. Irvine [17] showed that his results can be expressed in terms of a single parameter λ_*^2

$$\lambda_*^2 = \left(\frac{\rho_c A g \ell_*}{H_*} \cos\phi\right)^2 / (H_*/EA) \quad (9)$$

$$H_* = H/\cos\phi \quad (10)$$

The inclination angle is ϕ and ℓ_* is the inclined span.

Experiments performed in air and in water [25] confirmed mode crossover as predicted by Irvine. The value of the elastic stiffness was known only within a range of values, however, so that exact quantitative results were not possible. Nonetheless, Irvine's prediction lay within the range of possible values. Ramberg and Griffin [25] provided useful data for the added mass and damping coefficients for a cable in water. More recent experimental results for inclined cables were found to be in good agreement with theory [26].

The methodology by Irvine and Caughey [15] was followed by other authors. The natural frequencies of inclined parabolic (in the static configuration) cables were studied [41]; Irvine's results (using the same assumptions) were confirmed, and expressions were derived for the response spectrum. Blevins [4] has outlined Irvine's solution.

Stodola's method has been used to calculate numerically the natural frequencies and mode shapes of cables with arbitrary weight distribution, including lumped weights [30]. Crossover phenomena were also confirmed. An excellent account of the theory and application of cables is available [18].

Triantafyllou [37] used an asymptotic technique to derive the linear dynamics of large sag, inclined, inelastic marine cables. In the derivation it was assumed that the static properties of the cable vary slowly over a wavelength of the dynamic response and that the first order longitudinal dynamics are slowly varying (by necessity of the first requirement). He derived a solution for a catenary using the concept of effective tension as previously outlined [6] and a solution for a cable in a strong current. The solution for a catenary in the air is identical with a previous one [31] but was derived in a different manner and with different assumptions. This is fortunate and explains why the earlier solution [31] works even for small non-dimensional frequencies: Triantafyllou's assumption of slow variation takes over. The same holds for the validity of Triantafyllou's solution when the variation is not small, but the frequency is large. This theory was used to derive cable transfer functions, and comparisons were made with numerical (finite difference) solutions [38].

The same methodology has been used for the problem of an inclined, elastic cable with small sag [39].

Elasticity effects were included, but the assumption of quasi-static stretching -- i.e., elastic waves were allowed -- was not made. Two equations were derived asymptotically. One is similar to the large sag case; the other is new and reduces for inelastic cables to that derived by Routh in 1868 [28] for a cable suddenly pulled from one end. In the general case the equation is asymptotically in the form:

$$\frac{d^2}{ds^2}\left(\frac{q(s)}{\alpha(s)}\right) + Q(s)\left(\frac{q(s)}{\alpha(s)}\right) = 0 \quad (11)$$

where $q(s)$ is the transverse displacement, $\alpha(s)$ the local curvature of the static configuration, s the Lagrangian unstretched coordinate, and

$$Q(s) = \frac{m\omega^2}{EA} - \alpha^2(s)\frac{M}{m} \quad (12)$$

m is the mass per unit length of the cable, and M the mass augmented by the added mass per unit length (for a cable immersed in fluid).

For small sag-to-span ratios ϵ, $Q(s)$ is to first order in ϵ *a linear function of s. In the case of a horizontal* cable $Q(s)$ is a constant; depending on the balance of the two terms in the righthand side of equation (12), $Q(s)$ can be positive or negative, admitting sinusoidal or exponential solutions respectively. The transition from exponential to sinusoidal solutions coincides with the mode crossover phenomena of Irvine and Caughey [15]. The expression for the natural frequencies is more complex -- unless quasi-static stretching is assumed; and it becomes identical to that of Irvine -- because it accounts for elastic wave phenomena. A similar equation has been published for parabolic cables [34].

In the case of an inclined cable, there is a remarkable difference. The solution of equation (11) is expressible in terms of Airy functions, and a mode crossover never occurs. Instead, the natural frequencies become close, and the corresponding modes become hybrid; i.e. a mixture of symmetric and antisymmetric modes (Figure 4). The transition is governed by the parameter λ_*^2 as defined in equation (9), but the inclination angle has a minor effect on the natural frequencies (Figure 5) and a strong effect on the mode shape (Figure 4).

Figure 4. Hybrid modes of an inclined cable [39]

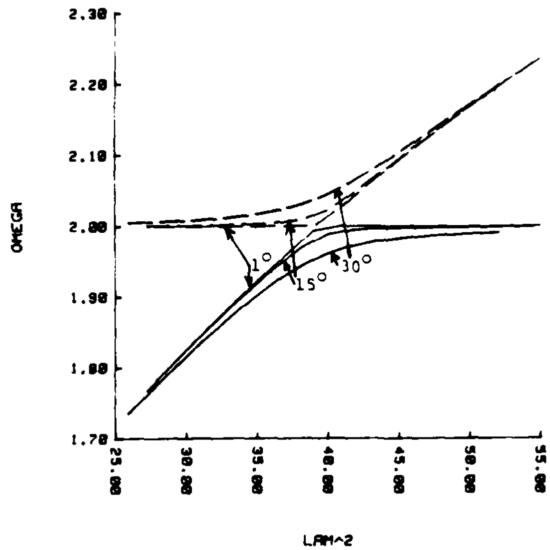

Figure 5. Effect of inclination angle on the first two natural frequencies of an elastic, small sag inclined cable. The frequency is non-dimensionalized with respect to the first natural frequency of a taut wire with the same characteristics [39]

All developments have been summarized and used to derive tables of natural frequencies [40].

Simpson provided the general framework for studying the motions of a cable, including torsional motion, and accounting for bending effects [34]. He provided solutions for small motions using perturbation expansion and proceeded to derive expressions for natural frequencies and impedances. He also considered the oscillatory motions of an elastic cable that is translating uniformly between its end supports [32]. He solved the linearized equations analytically by introducing approximations for a

shallow sag catenary. A significant change occurred in modal shape as the velocity of translation increased, including phase differences between the motions of two different points of the cable. The first natural frequency was found to decrease monotonically with speed; no general trend exists for the remaining frequencies; the result is frequency coalescence at certain speeds.

Gambhir and Batchelor [11] studied the vibrations of horizontal and inclined cables using the finite element technique. They compared straight and curved elements and found that fewer curved elements are needed for the same accuracy. A sensitivity analysis of natural frequency prediction was presented as a function of the number of elements used. They also presented results for specific examples and did not use non-dimensional quantities. In the case of horizontal cables they confirmed Irvine's crossover phenomena and presented results for a wide range of sag-to-span ratios. In the case of an inclined cable they showed that no crossover occurs while modes switch number of nodes in the manner indicated by Triantafyllou [39]. No discussion of this phenomenon is given in their analysis, and the mode shapes are not shown; the natural frequency plot clearly indicates a mode transition range, however.

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BOOK REVIEWS

GENERALIZED METHODS OF VIBRATION ANALYSIS

R.J. Harker
John Wiley and Sons, New York, NY
1983, 435 pages, $44.95

In his Preface, Professor Harker states that this book is intended as a reference work for professional engineers, but that is can also serve as a text. The book begins with three chapters on single-degree-of-freedom vibrations (89 pages). Two chapters on multi-degree-of-freedom vibrations discuss eigensolutions and forced response (66 pages). The balance of the book is given to chapters with the following titles:

Chapter 6	Torsional Vibration of Crankshafts
Chapter 7	Vibration Absorbers and Dampers
Chapter 8	Combined Linear and Angular Coordinates
Chapter 9	Single-mass Systems with Beam Elasticity
Chapter 10	Whirl of the Single-mass System
Chapter 11	Multimass Systems with Beam Elasticity
Chapter 12	Uniform Beams
Chapter 13	Whirling of Flexible Rotors
Chapter 14	Spatial Coordinates
Chapter 15	Circular Rings
Chapter 16	Experimental Methods

The scope of the book is limited to the steady-state response of linear systems, with the exception of a discussion of single-degree-of-freedom response to a step function and to a sequence of step functions. There is a section of four to 12 problems for each of the first 15 chapters, a total of 109 problems. The answers for all problems are given in a separate section.

There are two distinctive features of the book. The first is extensive use of tabulations for presenting results in summary form. This is consistent with the intended purpose of the book as a reference work for practicing engineers. The second is the extensive use of nondimensional quantities. The author feels that the use of dimensionless variables facilitates the tabular presentations, makes computation with a personal calculator feasible for more situations, and avoids difficulties with various systems of units. A summary tabulation of 14 dimensionless variables precedes Chapter 1. The reviewer finds that the extensive nondimensionalization leads to unfamiliar notation that will not be welcomed by the practicing professional who seeks to use this work as a reference.

The listing of chapter headings shows that the author has chosen to address a number of topics of practical interest. He has generally avoided matrix formulations for multi-degree-of-freedom systems, with the result that the chapter on crankshaft torsional vibrations is much like the *BICERA Handbook* or the multivolume work of Ker Wilson. The chapter on absorbers is detailed but appears to treat all situations in terms of two degrees of freedom, one representing the primary system and one the absorber. The chapter on combined linear and angular coordinates addresses an area of great practical importance usually given little attention in the typical text. The sections dealing with elastic deformation of beams, Chapters 9 through 13, are based on the flexibility concept. Unfortunately, the only eigensolution techniques considered for systems involving beam bending are exact solution of the characteristic equation for small systems, the Rayleigh approximation, and the Stodola method. The Myklestad-Prohl method is dismissed (not by name) as unwieldy. The Holzer method is discussed extensively for torsional and axial vibration eigensolutions, but it is not presented as a transfer matrix method.

This reviewer was dismayed with the frequent interchange between pounds mass and pounds force, both designated lb. The author evidently takes exception to Newton's third law in that he frequently employs inertia force terms for which there are no reactions in the universe. When metric units are used, they are

referred to as SI units, but density is given as kg/cm^3 and spring rate as N/cm, both throwbacks to the cgs system.

The general mathematical level of the book is low. Matrix methods, which have played such a major role in multi-degree-of-freedom vibration analysis in recent years, are used sparingly. No mention is made of the problem of linearizing the equations of motion for vibration study for a system that is nonlinear in gross motion. Because all transient phenomena are omitted, no mention is made of Fourier transforms, Laplace transforms, or convolution, even though all are well established techniques for linear vibrations. Similarly Lagrange's equations are not mentioned, although energy considerations are taken as the basis for establishing equivalent systems. The reviewer feels, regrettably, that he will not find this book to be of much service, either as a text or as a professional reference.

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PRINCIPLES OF ANALOG AND DIGITAL FREQUENCY ANALYSIS

J.T. Broch
Tapier Pub., Norwegian Institute of Technology
Trondheim, Norway, 1981, 172 pages, $20.00

J.T. Broch's book Principles of Analog and Digital Frequency Analysis covers two broad fields in a very short volume. But it is a successful attempt to explain to the reader complicated physical phenomena using simplified mathematical schemes. Even though the mathematical presentation is effective only for a reader with a good understanding of analytical and numerical mathematics, a user of the new vibration analysis techniques will be able to obtain a good picture of the new concepts used in analog and digital data processing.

Chapter 1 introduces the reader to the subject. The first five paragraphs of Chapter 2 explaining the Fourier transform and its properties are well presented and provide the mathematical foundation for the rest of the book. The next three paragraphs of Chapter 2 do not provide the reader with a clear physical meaning of the correlation and coherence functions, even though the mathematics is easy to follow.

The first paragraph in Chapter 3 is an excellent description of the statistical meaning of rms and probability density. Paragraphs 3.2 through 3.6 provide the reader with a good physical explanation of the basic concepts of analog filtering. The next paragraph -- on the processing of stochastic signals -- requires a background in operational mathematics and statistics.

The first two paragraphs of Chapter 4 provide a good description of the discrete Fourier transform; however, the level of operational mathematics is higher. The physical measurement of leakage is well presented in paragraph 4.3, but the effect of time truncation of a transient phenomena is not clearly explained. Paragraph 4.4 is a good presentation of the FFT (radix 2) numerical scheme, and the next paragraph is an excellent physical and mathematical description of the ZOOM function.

Paragraphs 4.6 and 4.7 are good basic explanations of the digital correlation and convolution functions. These paragraphs provide the reader with information that will help him understand the concepts shown in paragraph 2.9. The material presented in this paragraph will help in implementing a correlation or convolution routine on a computer when an FFT routine is already available.

Digital filtering techniques are presented in the paragraph 4.8. The necessary concepts and physical meanings are well explained. The appendices are good aids in understanding the material in the book.

This book comes at a time when all manufacturers of FFT spectrum analyzers are in a race to build multi-channel instruments with all the functions discussed by the author. The text will be helpful to anyone who intends to use multi-channel FFT analyzers and who needs to understand the physical and mathematical bases of analog and digital signal analysis. The book is also a good reference for any

scientist or engineer involved with the digital aspects of signal processing.

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NOISE AND NOISE CONTROL, VOL II

M.J. Crocker and F.M. Kessler
CRC Press, Inc., Boca Raton, FL
1982, 300 pages, $90.00

The first volume of this series by M.J. Crocker and A.J. Price was published by CRC first in 1975 and then in 1979. Its chapters have to do with the following broad topics: fundamentals of sound and vibration, human hearing and subjective response, instrumentation for sound and vibration, acoustics of enclosures, and architectural acoustics. The first volume is filled with clear discussions and well explained exhibits that make extremely good and informative reading. Happily, the content and quality of Volume II, with a few exceptions, are comparable to Volume I; collectively, the two books provide excellent reference material for both experienced and inexperienced readers.

The stated purpose of the second book is to use the principles developed in Volume I (and also in Volume II) to control noise and, to a limited extent, vibration. The book partially fulfills this purpose, especially with the first three chapters, which specifically deal with noise control. However, the last chapters on community noise regulations are more descriptive and explanative in nature and do not deal directly with noise control. Nevertheless, although these latter chapters do not directly meet the stated focus of the book, they are both necessary and useful for discussions of the entire field of noise control.

The first of the five chapters in the second volume is on principles of noise control, and it contains the expected sections: Source - Path - Receiver, Vibration Isolation, Absorbing Materials, Enclosures, and Damping. Careful reading, however, reveals some exceptional points. First, all of the discussions on noise control are clear and useful. I think the section on damping is the highlight of this chapter and was glad to see separate and distinct treatments of vibration damping and of vibration isolation. The author discusses the theory behind the measurement of damping and the differences between the measured data so obtained. Also, he advises caution on the use of damping for noise control -- an important concept often left out of books on noise control. Another nice feature of chapter one is that the author provides numerous examples to reinforce and provide further insight into the concepts discussed.

The second chapter discusses transmission loss (absorption is found in the first volume). The author presents the concepts and assumptions used in developing the theory, and he devotes an entire section to the relatively new concept of statistical energy analysis. This section contains one of the few well-documented explanations that I have seen of transmission loss test methods (field and lab) although, based on the references, it apparently was written several years ago. Not only are conventional test methods reviewed but also the newer techniques of sound intensity, using two microphones, and surface intensity, using an accelerometer and a microphone. The chapter's completeness is evidenced by discussion of the (A-weighted) normalized level difference and standards by ASTM and ISO, topics rarely found in books of this type. I believe this chapter is the strongest in the entire book.

The chapter on heating, ventilating, and air conditioning noise, co-authored by M.J. Crocker and A.J. Price is a reasonably complete discussion of the topic although references to the ASHRAE guides would have given more credence to some of the discussions. For example, the use of NC or PNC criteria is referenced to a 1957 book by L. Beranek. The latest ASHRAE guide, often considered a standard, also uses these concepts.

Community noise is a difficult topic to write about because of its changing nature, its socio-scientific basis, its diverse and uncontrolled sources, and emphasis determined by election results rather than need. As I mentioned earlier, there is little substantive discussion of noise control in this chapter; rather, there is a broadly ranging discussion on the effects of noise, the sources of community noise, and rating schemes. Much of this chapter is a restatement of

either the U.S. Environmental Protection Agency policy or those reports generated by U.S. government contractors. I think that an expansion of the 10-page discussion on noise sources would have been more in line with the purposes of the book. Noise metrics are used for measurement and quantification and are necessary to better determine problems caused by noise and the solutions resulting from noise control; therefore, a good, but short, discussion of descriptors is included. (See T. Schultz's Community Noise Rating, Second Edition, Applied Science Publishers, for a more thorough treatment.) Unfortunately, the good work presented in this chapter will probably not be read for some time because it appears that political and economic times have made these considerations moot in most federal and local jurisdictions.

The last chapter on laws, regulations, and standards is complete but somewhat out of date: the standards section is limited to a few that deal only with community noise. In general, this chapter is descriptive and emphasizes the older EPA, HUD, and OSHA regulations. To update this information the authors add footnotes at various places in the book to provide more recent data but with minimal description. The DOL guidelines on occupational noise, for example, have been withdrawn with no replacement, yet the book indicates otherwise. Fortunately, the major federal laws and regulations are discussed (OSHA, EPA, HUD, DOT, GSA, Bureau of Mines, DOD) and provide a valuable compilation for anyone looking into the effects of government regulation on noise control. State laws are surveyed in a table and provide an overview of them as they existed when the chapters were written.

The Index and layout of the book are very good; many of the numerous references are several years old. Most figures are well drawn, and all articles are well written. Although the book is not perfect, it is excellent; the two volumes would be useful to all practicing engineers working in acoustics and noise control. I plan to keep both within reach at my desk and recommend them highly.

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FUNDAMENTALS OF VIBRATION ENGINEERING

I.I. Bykhovsky
Robert E. Krieger Pub. Co., Huntington, NY, 1980

This book is a translation from the Russian language original published in 1969 and revised as an English language edition. It is claimed that four additional sections, dealing with different applications of vibration engineering, have been added for the English edition.

The book includes basic vibrations, vibrations of linear systems, parametric and nonlinear systems, energy dissipation, several chapters on dynamics of vibration generators and drives, vibration isolation, and special applications. The book is not written in the same manner and style as those North American texts usually adopted in engineering schools. The sequence of presentation is also different and is difficult to follow. Therefore, this book cannot be recommended as a text for engineering students; it might, however, be a useful reference because of its treatment of several problems dealing with engineering applications of vibrations.

The presentation and illustrations are not appealing. *Specifically, figure legends are missing except for the* figure number; all details are contained elsewhere in the descriptive text. Frequency response curves are plotted for slightly different forms of frequency ratios; namely,

$$\frac{\omega}{\omega_o} \text{ (for } o < \frac{\omega}{\omega_o} \leq 1) \qquad \text{and}$$

$$2 - \frac{\omega}{\omega_o} \text{ (for } 1 < \frac{\omega}{\omega_o} < \infty)$$

These are inconsistent with the standard form usually used, and do not provide any advantage. The treatment tends to be mathematical in approach. Physical interpretations are missing; for example, in the discussion of normal modes. The treatments of two- and multi-degree-of-freedom systems are too concise, and

no good examples are given. There are also a few printing errors.

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SHORT COURSES

APRIL

MODAL TESTING

Dates: April 3-6, 1984
Place: San Diego, California
Dates: August 14-17, 1984
Place: New Orleans, Louisiana
Objective: Vibration testing and analysis associated with machines and structures will be discussed in detail. Practical examples will be given to illustrate important concepts. Theory and test philosophy of modal techniques, methods for mobility measurements, methods for analyzing mobility data, mathematical modeling from mobility data, and applications of modal test results will be presented.

Contact: The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

DYNAMIC BALANCING SEMINAR/WORKSHOP

Dates: April 18-19, 1984
May 23-24, 1984
Place: Columbus, Ohio
Objective: Balancing experts will contribute a series of lectures on field balancing and balancing machines. Subjects include: field balancing methods; single, two and multi-plane balancing techniques; balancing tolerances and correction methods. The latest in-place balancing techniques will be demonstrated and used in the workshops. Balancing machines equipped with microprocessor instrumentation will also be demonstrated in the workshop sessions, where each student will be involved in hands-on problem-solving using actual armatures, pump impellers, turbine wheels, etc., with emphasis on reducing costs and improving quality in balancing operations.

Contact: R.E. Ellis, IRD Mechanalysis, Inc., 6150 Huntley Rd., Columbus, OH 43229 - (614) 885-5376.

ROTOR DYNAMICS

Dates: April 30 - May 4, 1984
Place: Syria, Virginia
Objective: The role of rotor/bearing technology in the design, development and diagnostics of industrial machinery will be elaborated. The fundamentals of rotor dynamics; fluid-film bearings; and measurement, analytical, and computational techniques will be presented. The computation and measurement of critical speeds vibration response, and stability of rotor/bearing systems will be discussed in detail. Finite elements and transfer matrix modeling will be related to computation on mainframe computers, minicomputers, and microprocessors. Modeling and computation of transient rotor behavior and nonlinear fluid-film bearing behavior will be described. Sessions will be devoted to flexible rotor balancing including turbogenerator rotors, bow behavior, squeeze-film dampers for turbomachinery, advanced concepts in troubleshooting and instrumentation, and case histories involving the power and petrochemical industries.

Contact: The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

FOURIER AND SPECTRAL ANALYSIS IN DYNAMIC SYSTEMS

Dates: April 30 - May 4, 1984
Place: Austin, Texas
Objective: This five day course will enable the participant to understand and apply the basic Fourier transform theory required to utilize the new digitally based Fourier and spectral analysis equipment. Lecture, demonstrations, discussions and lab will place emphasis upon a basic understanding of the digital processing of signals, including time and frequency domain characteristics, effects of sampling, windowing, statistical averaging, and some of the pitfalls present in collecting, processing, and interpreting data. Applications of the theory which will be discussed and/or demonstrated include dynamic system identification, signature analysis, random vibration,

transfer function identification, experimental modal analysis, acoustics, and noise characterization and transmission.

Contact: Continuing Engineering Studies, College of Engineering, The University of Texas at Austin, Austin, TX 78712 - (512) 471-3506.

MAY

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: May 7-11, 1984
Place: Boston, Massachusetts
Dates: June 4-8, 1984
Place: Santa Barbara, California
Dates: August 27-31, 1984
Place: Santa Barbara, California
Dates: September 17-21, 1984
Place: Ottawa, Ontario
Dates: October 15-19, 1984
Place: New York, New York
Dates: November 5-9, 1984
Place: San Francisco, California

Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos Street, Santa Barbara, CA 93105 - (805) 682-7171.

ELECTROEXPLOSIVES DEVICES

Dates: May 15-17, 1984
October 16-19, 1984
Place: Philadelphia, Pennsylvania

Objective: Topics will include but not be limited to the following: history of explosives and definitions; types of pyrotechnics, explosives and propellants; types of EEDs, explosive trains and systems, fuzes, safe-arm devices; sensitivity and functioning mechanisms; output and applications; safety versus reliability; hazard sources; lightning, static electricity, electromagnetic energy (RF, EMP, light, etc.), heat, flame, impact, vibration, friction, shock, blast, ionizing radiation, hostile environments, human error; precautions, safe practices, standard operating procedures; grounding, shorting, shielding; inspection techniques, system check-out trouble shooting and problem solving; safety devices, packaging and transportation; specifications, documentation, information sources, record keeping; tagging, detection and identification of clandestine explosives; reaction mechanisms, solid state reactions; chemical deactivation, disposal methods and problems, toxic effects; laboratory analytical techniques and instrumentation; surface chemistry.

Contact: E&P Affairs, The Franklin Research Center, 20th and Race Streets, Philadelphia, PA 19103 - (215) 448-1000.

MACHINERY VIBRATION ANALYSIS

Dates: May 15-18, 1984
Place: Nashville, Tennessee
Dates: August 14-17, 1984
Place: New Orleans, Louisiana
Dates: October 9-12, 1984
Place: Houston, Texas
Dates: November 27-30, 1984
Place: Lisle, Illinois

Objective: In this four-day course on practical machinery vibration analysis, savings in production losses and equipment costs through vibration analysis and correction will be stressed. Techniques will be reviewed along with examples and case histories to illustrate their use. Demonstrations of measurement and analysis equipment will be conducted during the course. The course will include lectures on test equipment selection and use, vibration measurement and analysis including the latest information on spectral analysis, balancing, alignment, isolation, and damping. Plant predictive maintenance programs, monitoring equipment and programs, and equipment evaluation are topics included. Specific components and equipment covered in the lectures include gears, bearings (fluid film and antifriction), shafts, couplings, motors, turbines, engines, pumps, compressors, fluid drives, gearboxes, and slow-speed paper rolls.

Contact: The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MACHINERY VIBRATION ENGINEERING

Dates: May 15-18, 1984
Place: Nashville, Tennessee
Dates: August 14-17, 1984
Place: New Orleans, Louisiana
Dates: October 9-12, 1984
Place: Houston, Texas
Dates: November 27-30, 1984
Place: Lisle, Illinois

Objective: Techniques for the solution of machinery vibration problems will be discussed. These techniques are based on the knowledge of the dynamics of machinery; vibration measurement, computation, and analysis; and machinery characteristics. The techniques will be illustrated with case histories involving field and design problems. Familiarity with the methods will be gained by participants in the workshops. The course will include lectures on natural frequency, resonance, and critical speed determination for rotating and reciprocating equipment using test and computational techniques; equipment evaluation techniques including test equipment; vibration analysis of general equipment including bearings and gears using the time and frequency domains; vibratory forces in rotating and reciprocating equipment; torsional vibration measurement, analysis, and computation on systems involving engines, compressors, pumps, and motors; basic rotor dynamics including fluid film bearing characteristics, critical speeds, instabilities, and mass imbalance response; and vibration control including isolation and damping of equipment installation.

Contact: The Vibration Institute, 101 West 55th Street, Clarendon Hills, IL 60514 - (312) 654-2254.

ROTORDYNAMIC INSTABILITY PROBLEMS IN HIGH-PERFORMANCE TURBOMACHINERY

Dates: May 28-30, 1984
Place: College Station, Texas

Objective: The third workshop continues the following basic objectives of the first two (held in 1980 and 1982): development of an increased understanding of rotordynamic instability mechanisms in high-performance turbomachinery; a sharing of experiences in diagnosing causes of unstable vibrations in operating turbomachinery, and in remedying them; documentation of the current state-of-the-art for analysis and design of stable turbomachinery; and suggestion of new directions for research aimed at resolving unstable turbomachinery problems.

Contact: Dr. John Vance or Dr. Dara Childs, Department of Mechanical Engineering, Texas A&M University, College Station, TX 77843 - (409) 845-1257/1268.

JUNE

VIBRATION DAMPING

Dates: June 17-21, 1984
Place: Dayton, Ohio

Objective: The utilization of the vibration damping properties of viscoelastic materials to reduce structural vibration and noise has become well developed and successfully demonstrated in recent years. The course is intended to give the participant an understanding of the principles of vibration damping necessary for the successful application of this technology. Topics included are: damping fundamentals, damping behavior of materials, response measurements of damped systems, layered damping treatments, tuned dampers, finite element techniques, case histories, problem solving sessions.

Contact: Michael L. Drake, Jessee Philips Center 36, 300 College Park Avenue, Dayton, OH 45469 - (513) 229-2644.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

INTERNATIONAL SYMPOSIUM ON STRENGTH OF MATERIALS AND STRUCTURAL COMPONENTS AT SONIC AND ULTRASONIC LOADING FREQUENCIES

Revised Date

The date for this international symposium, which will be held at the Institute for Problems of Strength, Kiev, USSR, has been changed to September 25-28, 1984. The due date for abstracts has also been extended. Proposals for papers should be presented by the authors to the Organizing Committee in the form of 200 - 400 word abstracts (without figures) before May 15, 1984. Proposals without abstracts will not be considered. The full manuscripts should be presented at the symposium for the purpose of publishing its Proceedings. Abstracts arriving after the deadline will be considered for additional poster presentation.

For further information contact: Organizing Committee, USSR 252014 Kiev 14, Timiryazevskaya str., 2, Institute for Problems of Strength.

ABSTRACTS FROM THE CURRENT LITERATURE

ABSTRACT CONTENTS

AVAILABILITY OF PUBLICATIONS ABSTRACTED

Government Reports:	NTIS Springfield, VA 22151 (unless otherwise indicated)
Ph.D. Dissertations:	University Microfilms International 300 N. Zeeb Rd. Ann Arbor, MI 48106
U.S. Patents:	Commissioner of Patents Washington, DC 20231
Chinese Publications (CSTA):	International Information Service, Ltd. P.O. Box 24683 ABD Post Office Hong Kong (In Chinese or in English translation)

In all cases appropriate order numbers should be used (last line of citation).

When not available in local libraries, copies of the majority of papers or articles may be obtained at Engineering Societies Center, 345 E. 47th St., New York, NY 10017, or Library of Congress, Washington, DC.

None of the publications are available at SVIC or at the Vibration Institute, except those generated by either organization.

A list of periodicals scanned in published in issues 1, 6, and 12.

MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 487, 562)

84-430

The Steady-State Response of a Cantilevered Rotor with Skew and Mass Unbalances

R.C. Benson

Univ. of Rochester, Rochester, NY 14627, J. Vib. Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 456-460 (Oct 1983) 6 figs, 12 refs

Key Words: Rotors, Cantilever rotors, Periodic response, Unbalanced mass response

The steady state response of a cantilevered rotor with skew and mass unbalances is studied, with special attention to the effects due to skew. Rotor critical speeds are studied for their number and severity, with results presented in a compact nondimensional form.

84-431

Stability Problems of Rotor Systems

T. Iwatsubo

The Faculty of Engrg., Kobe Univ., Rokkodai Nada Kobe 657, Japan, Shock Vib. Dig., 15 (8), pp 13-24 (Aug 1983) 196 refs

Key Words: Rotors, Dynamic stability, Turbines, Compressors, Pumps, Bearings, Reviews

This article is a review of the literature published from 1980 to 1982 on vibration problems in rotor dynamics, especially instability problems. Included are general vibration problems and theoretical and numerical approaches to free and forced vibrations; vibration problems of turbines, compressors, pumps, and bearings; flow-induced forces due to seals and impellers; parametric excitations due to couplings and unsymmetric stiffness of rotor shafts; torsional vibration; gears; monitoring (diagnosis); and control.

84-432

Simplified Techniques for Studying Nonlinear Shaft Vibration Problems

L. Vassilopoulos and P.K. Ghosh

Maritech, Inc., Belmont, MA, Pres. at the VIII Congress of the Pan-American Institute of Naval Engrg., Washington, DC, Sept 12-17, 1983, 53 pp, 16 figs, 17 refs

Key Words: Shafts, Axial vibration, Flexural vibration, Torsional vibration

A brief review of the general subject of nonlinear vibrations is presented and the major mechanisms that can cause nonlinearities in main propulsion shafts vibrating in axial, torsional and transverse modes are described. Simplified formulae are presented for assessing the influence of nonlinearities on the fundamental natural frequencies of interest. The determination of the forced response characteristics of simplified shaft systems is reviewed for both deterministic and random loads. Included are a bibliography on nonlinear vibrations, references on nonlinear ship oscillations and offshore platform motions and a simplified computer program to analyze a nonlinear system using the Newmark integration method.

84-433

Transient Response of Simple Rotor Systems under Sudden Unbalance (Blade Loss) (*Das Einschwingverhalten einfacher Rotorsysteme bei plötzlicher Unwucht (Schaufelbruch)*)

R. Gasch and P. Reinheimer

Institut fur Luft- und Raumfahrt, TU Berlin, Germany, Forsch. Ingenieurwesen, 49 (5), pp 143-152 (1983) 19 figs, 7 refs

(In German)

Key Words: Transient response, Rotors, Blade loss dynamics

A sudden unbalance of Laval rotors (a disk on a round elastic shaft) causes the rotor to vibrate more or less violently, before it returns to a stationary state. This paper illustrates the effect of damping, bearing anisotropy, shaft anisotropy, and the angular position of the suddenly occurring unbalance on the transient response of the system.

METAL WORKING AND FORMING

84-434

Dynamic Analysis and Optimal Selection of Parameters of a Finite Element Modeled Lathe Spindle under Random Cutting Forces

A.M. Sharan, S. Sankar, and T.S. Sankar

Dept. of Mech. Engrg., Concordia Univ., Montreal, Quebec, Canada, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 467-474 (Oct 1983) 9 figs, 8 tables, 17 refs

Key Words: Machine tools, Lathes, Random excitation, Cutting

The dynamic analysis of an elastically supported lathe spindle-workpiece system subjected to random cutting forces is presented. The stochastic partial differential equation characterizing the behavior of the system was formulated from the Euler-Bernouli equation. The effect of bearing stiffness and damping, and bearing spacing on the mean square displacmeent were studied. A direct search optimization technique was carried out to select optimal bearing stiffness and the bearing spacing. Results are presented in the form of plots and tables.

84-435
An Investigation of Tool Wear and the Vibration Spectrum in Milling
N.K. Mehta, P.C. Pandey, and G. Chakravarti
Dept. of Mech. and Industrial Engrg., Univ. of Roorkee, Roorkee 247667, India, Wear, 91 (2), pp 219-234 (Nov 1, 1983) 9 figs, 7 tables, 21 refs

Key Words: Machine tools, Wear, Vibration effects

The findings of an experimental study conducted on carbide face milling cutters, where the effect of the interaction between the tool wear and the vibrations that occur during the process was investigated, are reported. The effect of the machine tool-cutting tool-workpiece system stiffness on tool wear was also investigated.

STRUCTURAL SYSTEMS

BUILDINGS

(Also see Nos. 452, 518)

84-436
Preliminary Analysis of the Seismic Vulnerability of Selected Buildings at Fort Ord, California, Using the Rapid Seismic Analysis Procedure
T.K. Lew
Construction Engrg. Res. Lab. (Army), Champaign, IL, Rept. No. CERL-TR-M-327, 81 pp (Mar 1983) AD-A130 924

Key Words: Buildings, Vulnerability, Earthquake damage, Prediction techniques, Damage prediction

A preliminary evaluation of the seismic vulnerability of a selected group of 17 essential and high-potential-loss buildings at Fort Ord, CA, was conducted using the Navy's Rapid Seismic Analysis procedure. This procedure estimates the potential earthquake ground-shaking effects on buildings, including estimated damage and the cost of these damages. In addition a list of recommended modifications to enhance the accuracy and capabilities of this procedure was also developed.

84-437
On a Problem of Structural Dynamics
C. Cubeddu
Faculty of Science, Mathematical Inst., Univ. of Cagliarai, via Genovesi, 09100 Cagliari, Italy, J. de Mecanique Theor. Appl., 2 (4), pp 559-566 (1983) 2 figs, 7 refs

Key Words: Buildings, Multistory buildings, Earthquake response, Seismic analysis, Standards and codes

The equivalent static forces induced by earthquakes in shear-type frame structures is expressed in a simplified form. It is shown that structural response to earthquakes cannot be represented just by the first three modes of vibration as currently stipulated by the Italian Seismic Code.

84-438
Vibration Testing of an Epoxy-Repaired Reinforced Concrete Test Structure
G.N. Owen, I.O. Egbuonye, O. Kustu, and R.E. Scholl
URS/John A. Blume and Associates, San Francisco, CA, Rept. No. JAB-10145-3, 98 pp (Mar 1983) DE83011379

Key Words: Buildings, Reinforced concrete, Vibration tests

A full-scale, 4-story reinforced concrete structure, deliberately damaged by forced vibration in 1974, was repaired by the epoxy-injection method and retested in 1979 using the same reciprocating-mass vibration generator. The program

consisted of a series of tests, beginning with low-amplitude vibrations, followed by forced vibrations, increased into the range of inelastic response of the structure.

84-439

Analysis of Damaged Concrete Frame Buildings

M.S.L. Roufaiel and C. Meyer

Dept. of Civil Engrg. and Engrg. Mechanics, Columbia Univ., New York, NY, Rept. No. NSF/CEE-81-21359-1, 163 pp (May 1983)

PB83-239483

Key Words: Buildings, Reinforced concrete, Earthquake damage, Seismic analysis

A general analysis procedure is presented for simulating the earthquake response of reinforced concrete frame buildings which may or may not have been damaged during previous exposures to strong ground motions. The establishment of this analysis procedure requires the completion of the following tasks: the accurate modeling of the behavior of general reinforced concrete frame members subjected to strong cyclic loads, the definition of a damage parameter, which correlates well with the structure's residual strength and stiffness, and which is suitable for subsequent reliability analyses, and the establishment of a procedure for the dynamic analysis of damaged concrete frames.

FOUNDATIONS

84-440

Numerical Techniques for the Evaluation of Soil-Structure Interaction Effects in the Time Domain

E. Bayo and E.L. Wilson

Earthquake Engrg. Res. Ctr., Univ. of California, Berkeley, CA, Rept. No. UCB/EERC-83/04, NSF/CEE-83011, 176 pp (Feb 1983)

PB83-245605

Key Words: Interaction: soil-structure, Finite element technique, Time domain method

A time domain finite element method that efficiently solves the three dimensional soil-structure interaction problem is presented. In addition to all the factors currently considered by frequency domain approaches this new method allows the consideration of the nonlinear effects in the structure and foundation (separation of base mat from soil or nonlinear material).

UNDERGROUND STRUCTURES

84-441

Testing of Reduced-Scale Concrete MX-Shelters Experimental Program

J.I. Daniel and D.M. Schultz

Ballistic Missile Office, Norton AFB, CA, Rept. No. BMO-82-017, 25 pp (June 29, 1983)

AD-A130 325

Key Words: Underground structures, Protective shelters, Missile silos, Model testing, Nuclear explosion effects

An experimental program involving construction and testing of reduced-scale concrete horizontal MX-missile shelters was conducted. The program consisted of 43 shelter specimens tested under static loading conditions. Applied loads modeled forces that might occur on the shelters from a nearby nuclear weapon attack.

84-442

1/5 Size VHS Series Blast and Shock Simulations

M. Noble

Ballistic Missile Office, Norton AFB, CA, Rept. No. BMO-82-105, 31 pp (June 29, 1983)

AD-A130 319

Key Words: Missile silos, Protective shelters, Underground structures, Blast-resistant structures, Blast response, Shock response, Simulation

The simulation objective of the 1/5 verifiable horizontal shelter (test series was to demonstrate the capability of a high explosive simulation technique (HEST) simulator to adequately duplicate complex airblast waveform loadings. A principal feature of the HEST design was the requirement to produce double-peaked resultant overpressures.

84-443

Laboratory Investigation of Expansion, Venting, and Shock Attenuation in the MX Trench

J.K. Gran, J.R. Bruce, and J.D. Colton

SRI International, Menlo Park, CA, Rept. No. BMO-82-003, 25 pp (June 29, 1983)

AD-A130 318

Key Words: Missile silos, Shock wave attenuation, Underground structures, Protective shelters

An experimental program using 1/26-scale models of a buried concrete trench was conducted to study the dynamics of expansion and venting caused by an airblast propagating down the trench, and to study the effects of the expansion and venting on the attenuation of the airblast. The trench models were made of steel fiber-reinforced concrete and were buried in sand. The airblast was produced with an explosively driven shock tube. Expansion and venting dynamics of short trench sections were studied for flat-topped pressure pulses ranging from 700 psi to 2600 psi.

84-444
Protective Vertical Shelters

I. Narain, J. Stephens, and G. Landon

Ballistic Missile Office, Norton AFB, CA, Rept. No. BMO-81-296, 39 pp (June 1983)

AD-A130 315

Key Words: Missile silos, Protective shelters, Blast resistant structures, Underground structures, Air blast, Ground shock, Model testing, Shock tests

The response of buried vertical MX shelters to vertical airblast and to airblast-induced ground-shock loadings is examined. Three tests were conducted on 1/6 scale reinforced concrete models to investigate the effects of site geology and structural detail on shelter response. The experimental data provided an insight into shelter response and was also used to evaluate the accuracy of pretest calculations and predictions.

84-445
Physical Modeling Techniques for Missile and Other Protective Structures

T. Krauthammer and C.D. Sutton

ASCE, New York, NY, 420 pp (June 29, 1983) (Pres. at ASCE Natl. Sping Convention, Las Vegas, NV, Apr 1982)

AD-A130 314

Key Words: Missile silos, Protective shelters, Underground structures, Model testing, Shock tests

Contents: The Use of Physical Models in Development of the MX Protective Shelter; Testing of Reduced-Scale Concrete MX-Shelters - Specimen Construction; Testing of Reduced-Scale Concrete MX-Shelters - Experimental Program; Testing of Reduced-Scale Concrete MX-Shelters - Instrumentation and Load Control; Blast and Shock Field Test Management; A Comparison of Nuclear Simulation Techniques on Generic MX Structures; Instrumentation for Protective Structures Testing; Finite Element Dynamic Analysis of the DCT-2 Model E; MX Basing Development Derived from H.E. Testing; 1/5 Size VHS Series Blast and Shock Simulations; Small-Scale Tests of MX Vertical Shelter Structures; Laboratory Investigation of Expansion, Venting, and Shock Attenuation in the MX Trench; Dynamic Cylinder Test Program; Protective Vertical Shelters; and Determination of Soil Properties through Ground Motion Analysis.

84-446
MX Basing Design Development Derived from H.E. Testing

D.M. Cole

Air Force Contract Management Div., Los Angeles, CA, Rept. No. AFCMD/82-017, 57 pp (June 29, 1983)

AD-A130 320

Key Words: Missile silos, Protective shelters, Underground structures, Blast resistant structures, Shock tests

The large size testing associated with the buried trench, horizontal and vertical shelter basing concepts is evaluated for its role in the development of structural design concepts. The major impact of the testing was in general to revise baseline concepts and to develop confident design and analysis procedures.

84-447
Use of Physical Models in Development of the MX Protective Shelter

E. Sevin

Ballistic Missile Office, Norton AFB, CA, Rept. No. BMO-82-126, 28 pp (June 29, 1983)

AD-A130 327

Key Words: Underground structures, Protective shelters, Hardened installations, Missile silos, Shock tests

The design candidate MX protective shelters made extensive use of engineering data developed from tests on physical models. This paper describes the effort associated with structural hardening of the three principal MX shelter concepts: horizontal shelter, vertical shelter, and shallow buried trench. Primary emphasis is on the trench concept.

84-448
Finite Element Dynamic Analysis of the DCT-2 Model
B.L. Bingham
Air Force Contract Management Div., Los Angeles, CA, Rept. No. AFCMD/82-013, 28 pp (June 29, 1983)
AD-A130 328

Key Words: Finite element technique, Cylindrical shells, Underground structures, Protective shelters, Reinforced concrete, Missile silos, Explosion effects, Shock tests

This report discusses quasi three-dimensional finite element dynamic analysis performed for a buried reinforced concrete cylindrical shell explosive test. The test included two horizontal ICBM shelter models with rectangular roof cut-outs, inner steel liners, longitudinal interior rails, and two different thickness to inner radius ratios (0.18 and 0.28). Both models were subjected to a combined axial and transverse simulated nuclear environment.

84-449
Small-Scale Tests of MX Vertical Shelter Structures
J.K. Gran, J.R. Bruce, and J.D. Colton
Ballistic Missile Office, Norton AFB, CA, Rept. No. BMO-82-003, 26 pp (June 29, 1983)
AD-A130 392

Key Words: Missile silos, Protective shelters, Underground structures, Reinforced concrete, Model testing, Scaling, Blast loads, Air blast, Shock tests

The purpose of this research was to assess the applicability of geometric scaling at very small scale to study the response of buried reinforced concrete vertical shelter structures subjected to airblast loading. The approach was to build and test two 1/30-scale models and compare the responses with those from corresponding 1/6-scale tests. One of the structures tested was designed to respond elastically, and the other was designed to respond inelastically.

84-450
Dynamic Cylinder Test Program
J.E. Stephens
Ballistic Missile Office, Norton AFB, CA, Rept. No. BMO-82-020, 39 pp (June 29, 1983)
AD-A130 317

Key Words: Missile silos, Underground structures, Reinforced concrete, Protective shelters, Ground shock, Nuclear weapons effects

The response of buried horizontal MX missile shelters to simulated nuclear airblast and airblast induced ground shock loadings is investigated. Two tests were conducted on scaled reinforced concrete models to examine the effect of structural variations on shelter response and to characterize the loadings across the shelter soil interface. Pretest calculations were performed for each test. The effectiveness of the calculation techniques was evaluated through comparison of the test and predicted results.

HARBORS AND DAMS

84-451
Random Vibration Analysis of Structures under Flow Fluctuating Pressure
Zeng Zhao Yang
J. Hydraulic Engrg., 1, pp 15-26 (1983)
CSTA No. 627-83.03

Key Words: Hydraulic systems, Random vibration, Fluid-induced excitation, Stochastic processes

The application of the stochastic vibration theory to the flood discharge structure is discussed. Through the summation of correlation functions of the multi-random process, the relationship between the fluctuating pressure of a point and that of an area is studied, the related formula is developed and demonstrates that the average fluctuating pressure on a given surface is inversely proportional to the square root of the discharge area.

POWER PLANTS

84-452
Combined Dynamic Effects of Correlated Load Processes
Yi-Kwei Wen and H.T. Pearce
Univ. of Illinois at Urbana, IL 61801, Nucl. Engrg. Des., 75 (2), pp 179-189 (May 1983) 9 figs, 16 refs

Key Words: Buildings, Nuclear power plants, Dynamic response, Seismic response

A large number of loadings on structures, particularly nuclear structures, are random and dynamic in nature and may be

generated from common or related sources (storms, earthquakes, and accidents). The combination of load effects which may be nonlinear, dynamic and statistically dependent is therefore an important issue in the assessment of safety and performance of a nuclear structure over its lifetime. This paper summarizes the latest developments in this area with emphasis on the versatile method of analysis based on a consideration of load coincidence. The validity and accuracy of this method is established by comparison with other methods and Monte Carlo simulations.

84-453

Leakage Flow-Induced Vibrations of Reactor Components

T.M. Mulcahy

Components Technology Div., Argonne Natl. Lab., Argonne, IL 60439, Shock Vib. Dig., 15 (9), pp 11-18 (Sept 1983) 30 refs

Key Words: Nuclear reactor components, Fluid-induced excitation, Reviews

Secondary flows through narrow gaps in reactor component supports, which are much smaller than but parallel to the primary coolant flow, occasionally are the excitation source for significant flow-induced vibrations. These so-called leakage flow problems are reviewed in this article for the purpose of identifying design features and excitation sources that should be avoided.

84-454

Verification of Experimental Modal Modeling Using HDR (Heissdampfreaktor) Dynamic Test Data

M.G. Srinivasan, C.A. Kot, and B.J. Hsieh

Argonne Natl. Lab., Argonne, IL, Rept. No. CONF-830805-11, 15 pp (1983) (Intl. Conf. Struc. Mechanics in Reactor Tech., Chicago, IL, Aug 22, 1983) DE83009431

Key Words: Modal models, Parameter identification technique, Nuclear power plants

Experimental modal modeling involves the determination of the modal parameters of the model of a structure from recorded input-output data from dynamic tests. Though commercial modal analysis algorithms are being widely used in many industries their ability to identify a set of reliable modal parameters of an as-built nuclear power plant structure has not been systematically verified. This paper describes the effort to verify MODAL-PLUS, a widely used modal analysis code, using recorded data from the dynamic tests performed on the reactor building of the Heissdampfreaktor, situated near Frankfurt.

84-455

Transient Analysis of Blowdown Thrust Force under PWR LOCA

T. Yano, N. Miyazaki, and T. Isozaki

Div. of Nuclear Safety Res., Tokai Res. Establishment, Japan Atomic Energy Res. Inst., Tokai-Mura, Naka-gun, Ibaraki-ken, Japan, Nucl. Engrg. Des., 75 (1), pp 157-168 (Apr 1983) 20 figs, 1 table, 13 refs

Key Words: Nuclear reactors, Pipe whip

The analytical results of blowdown characteristics and thrust forces were compared with the experiments, which were performed as pipe whip and jet discharge tests under the Pressurized Water Reactor Loss-of-Coolant Accident (PWR LOCA) conditions. The blowdown thrust forces were obtained by Navier-Stokes momentum equation for a single-phase, homogeneous and separated two-phase flow, assuming critical pressure at the exit if a critical flow condition was satisfied.

84-456

Multi-Dimensional Arbitrary Lagrangian-Eulerian Method for Dynamic Fluid-Structure Interaction (LMFBR)

C.Y. Wang and W.R. Zeuch

Argonne Natl. Lab., Argonne, IL, Rept. No. Conf-820601-32, 36 pp (1982) (ASME Pressure Vessel and Piping Conf., Orlando, FL, June 27, 1982) DE83010577

Key Words: Nuclear reactor components, Nuclear reactor containment, Interaction: structure-fluid

This paper describes an arbitrary Lagrangian-Eulerian method for analyzing fluid-structure interactions in fast-reactor containment with complex internal structures. The fluid transient can be calculated either implicitly or explicitly, using a finite-difference mesh with vertices that may be moved with the fluid (Lagrangian), held fixed (Eulerian), or moved in any other prescribed manner (hybrid Lagrangian Eulerian).

84-457

Analytical Method for Solving Fluid-Structure Interactions in BWR Pressure Suppression Pool

K. Namatame, Y. Kukita, I. Takeshita, and Y. Shimoda

Japan Atomic Energy Res. Inst., Tokai-mura, Ibaraki-ken, 319-11, Japan, Nucl. Engrg. Des., 75 (1), pp 5-11 (Apr 1983) 8 figs, 2 tables, 8 refs

Key Words: Nuclear reactors, Interaction: structure-fluid

An analytical method is developed for solving the fluid-structure interactions (FSI) associated with hydraulic transients in the Boiling Water Reactor (BWR) pressure suppression pool during a hypothetical loss-of-coolant accident. The method is applied to quantitative evaluation of the FSI effect on test data obtained from a large scale pressure suppression test which was performed to investigate the pressure oscillations in the pool induced by unstationary steam condensation.

VEHICLE SYSTEMS

GROUND VEHICLES

84-458

Railroad Induced Vibrations, New Bern, North Carolina, August 10 and 11, 1983

North Carolina Coastal Energy Impact Program, Raleigh, NC, Rept. No. CEIP-24, NOAA-83071804, 16 pp (Mar 1983)

PB83-233221

Key Words: Railroad trains, Vibration excitation

Coal trains using the rail line in New Bern, NC pass within one block of 17 buildings on the National Register of Historic Sites. Local concerns about the effect of train-caused vibrations led to the measurement and analysis of such vibrations and their effects on historic structures. 158 measurements were made at three sites.

84-459

Dynamic Analysis to Establish Normal Shock and Vibration of Radioactive Material Shipping Packages

S.R. Fields

Hanford Engrg. Dev. Lab., Richland, WA, Rept. No. HEDI-TME-83-8, 53 pp (July 1983)

NUREG/CR-2146-V2

Key Words: Shipping containers, Railroad cars, Vibration response, Shock response, Simulation

The CARDS (cask rail car dynamic simulator) model was modified to simulate the cask-rail car systems used in rail car coupling tests. An assessment of how well CARDS simulates the behavior of these cask-rail car systems was made by comparing calculated and experimental values of four response variables.

84-460

Wheel/Rail Force Measurement at the Washington Metropolitan Area Transit Authority. Phase 2. Volume 1. Analysis Report

J.A. Elkins

Analytical Sciences Corp., Reading, MA, Rept. No. DOT-TSC-UMTA-82-28, UMTA-MA-06-0025-83-1, 81 pp (June 1983)

PB83-245472

Key Words: Interaction: rail-wheel

Analytical and experimental studies are being conducted to relate transit truck design characteristics, wheel/rail forces, and wheel/rail wear rates, in order to provide options for reducing the wear rates of wheels and rails experienced by transit properties and minimizing system life cycle costs of vehicle and track components, while maintaining or improving equipment performance.

84-461

Wheel/Rail Force Measurement at the Washington Metropolitan Area Transit Authority. Phase 2. Volume 2. Test Report

P.J. Boyd, J.P. Zaiko, and W.L. Jordan

ENSCO, Inc., Springfield, VA, Rept. No. DOT-TSC-UMTA-83-1, UMTA-MA-06-0025-83-2, 93 pp (June 1983)

PB83-245480

Key Words: Interaction: rail-wheel

An expanded Phase II measurements program has been planned and implemented in order to: obtain onboard

wheel/rail force measurements over a representative range of the Washington Metropolitan Area Transit Authority's (WMATA's) operation conditions; obtain data to quantify the load environment of direct fixation fasteners and evaluate the influence of changes in fastener characteristics on performance; evaluate the influence of taper and suspension modification on high speed stability; and assess the feasibility of a retrofit to the WMATA truck to improve curving performance.

84-462

The Reflection of Road Traffic Noise

D.C. Hothersall and S. Simpson

School of Civil and Struc. Engrg., Univ. of Bradford, Bradford BD7 1DP, UK, J. Sound Vib., 90 (3), pp 399-405 (Oct 8, 1983) 4 figs, 6 refs

Key Words: Traffic noise, Sound waves, Wave reflection

In the UK prediction method for L_{10} noise levels from road traffic single figure corrections are used to allow for the effects of reflecting facades. In this paper simple expressions are proposed as improved corrections. These are derived for facades lying parallel to the road by using geometrical reflection theory and the equations for distance and angle of view effects given in the UK prediction method. The corrections are compared with the results of computer simulations and show good agreement.

SHIPS

84-463

Prediction of Motions and Structural Damage of Two Colliding Vessels

P.Y. Chang

Hydronautics, Inc., Laurel, MD, Rept. No. TR-8029-3-VOL-1, MA-RD-940-83041, 30 pp (Apr 1983) PB83-238220; TR-8029-3-VOL-2, MA-RD-940-83008, 108 pp (Apr 1983) PB83-238238; TR-8029-3-VOL-3, MA-RD-940-83007, 44 pp (Apr 1983) PB83-238246

Key Words: Collision research (ships), Damage predictions, Computer programs, Mathematical models

This report, presented in three volumes, contains the methodology and associated computer programs for the prediction of damage to the striking and struck ships involved in a collision. The upper and lower bound principles of the collapse theorems are used to obtain approximate, but reliable, predictions of the penetration of the struck ship and the crushed length of the striking bow. The methodology can also be applied to the analysis of actual collisions from a detailed examination of actual collision damage.

AIRCRAFT

(Also see Nos. 489, 531, 569, 576)

84-464

Acoustic Measurement of a Full-Scale Coaxial Hingeless Rotor Helicopter

R.L. Peterson and M. Mosher

NASA Ames Res. Ctr., Moffett Field, CA, Rept. No. A-9301, NASA-TM-84349, 127 pp (June 1983) N83-28986

Key Words: Helicopter noise, Noise measurement

Acoustic data were obtained during a full-scale test of the XH-59A advancing blade concept technology demonstrator in a 40- by 80-foot wind tunnel. The XH-59A is a research helicopter with two coaxial rotors and hingeless blades. Performance, vibration, and noise at various forward speeds, rotor lift coefficients and rotor shaft angles of attack were investigated.

84-465

Acoustic Measurement of the X-Wing Rotor

M. Mosher

NASA Ames Res. Ctr., Moffett Field, CA, Rept. No. A-9080, NASA-TM-84292, 109 pp (June 1983) N83-28985

Key Words: Helicopter noise, Noise measurement

Noise measurements of a stoppable X-wing rotor system model, tested in a 40- by 80-foot wind tunnel, are summarized. Performance, control system stability, and noise of the model were investigated at various forward speeds, tip speeds, collective blade angles, jet blowing velocities, and model attack angles. The model was tested in the rotating wing helicopter configuration, in the fixed wing configuration, and in wing configurations between the two.

84-466

Propeller Noise Prediction

W.E. Zorumski

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-85636, 61 pp (May 1983) (Pres. at Acoustical Soc. of America Mtg., Cincinnati, May 10, 1983)
N83-28984

Key Words: Helicopter noise, Noise prediction

Analytic propeller noise prediction involves a sequence of computations culminating in the application of acoustic equations. The prediction sequence currently used by NASA in its ANOPP (aircraft noise prediction) program is described. The elements of the sequence are called program modules. The first group of modules analyzes the propeller geometry, the aerodynamics, including both potential and boundary layer flow, the propeller performance, and the surface loading distribution. The second group of modules deals with the actual noise prediction, based on data from the first group.

84-467

Helicopter Noise Survey Conducted at Norwood, Massachusetts on April 27, 1983

S.R. Albersheim

Office of Environment and Energy, Fed. Aviation Admn., Washington, DC, Rept. No. FAA/EE-83-6, 30 pp (June 1983)
AD-A131 053

Key Words: Helicopter noise, Noise measurement

A noise measurement survey of helicopter operations was conducted to gather needed information for defining noise problems with in-service helicopter operations at a general aviation airport in a suburban area. Noise level data were sampled over a period of approximately 8 hours.

84-468

Development of Rotorcraft Interior. Noise Control Concepts. Phase 1: Definition Study

C.A. Yoerkie, J.A. Moore, and J.E. Manning

Sikorsky Aircraft Div., United Technologies Corp., Stratford, CT, Rept. No. SER-510126, NASA-CR-166101, 211 pp (May 1983)
N83-30166

Key Words: Helicopter noise, Noise source identification, Noise path diagnostics, Interior noise

A description of helicopter noise, diagnostic techniques for source and path identification, an interior noise prediction model, and a measurement program for model validation are provided.

84-469

Acoustics of Rotors Utilizing Circulation Control

M. Mosher

NASA Ames Res. Ctr., Moffett Field, CA, J. Aircraft, 20 (11), pp 946-952 (Nov 1983) 11 figs, 2 tables, 13 refs

Key Words: Helicopter noise, Noise generation

The acoustic characteristics of circulation-controlled rotors are examined by comparing data collected in a 40 x 80 foot wind tunnel from three full-scale rotors: X-wing rotor, circulation control rotor, and conventional rotor.

84-470

Impact and Vibration Testing of a Modified UH-1 Crew Seat

D.F. Shanahan, J.L. Haley, J.C. Johnson, J.H. Wells, and H. Knoche

Army Aeromedical Res. Lab., Fort Rucker, AL, Rept. No. USAARL-83-10, 85 pp (June 1983)
AD-A130 279

Key Words: Helicopter seats, Vibration damping

The German Air Force has developed a modified UH-1 pilot seat designed to improve comfort by increasing support to the thigh and lower back, providing better vibration dampening and increasing cold weather comfort. This seat was tested for vibration dampening, pilot acceptance, and impact tolerance in a side-by-side test with the standard UH-1 seat.

84-471

Lateral Attenuation of Aircraft Noise

C.J.J. Ruijgrok

Delft Univ. of Tech., Delft, The Netherlands, J.

Aircraft, 20 (11), pp 953-956 (Nov 1983) 8 figs, 8 refs

Key Words: Aircraft noise, Noise reduction

Lateral attenuation of aircraft noise comprises all of the losses in addition to spherical spreading and atmospheric absorption. The phenomenon is primarily due to ground interference effects and is often regarded as a function of source-receiver distance and elevation angle. In this paper theoretical predictions are made in order to examine the consistency of existing empirical data on lateral noise attenuation.

84-472

Prediction of Aircraft Interior Noise Using the Statistical Energy Analysis Method

V.R. Miller and L.L. Faulkner

Flight Dynamics Lab., Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 512-518 (Oct 1983) 6 figs, 18 refs

Key Words: Aircraft, Interior noise, Noise prediction, Statistical energy methods

An analytical model is developed to predict the transmission of noise into an airplane interior through the fuselage sidewall by the statistical energy analysis (SEA) method. The fuselage structure is represented as a series of curved, isotropic plates, the isotropic representation resulting from the effects of smearing out the stiffeners. Evaluation of the model was made using measured full-scale acoustic data from both an adhesively bonded and a mechanically fastened airplane fuselage structure.

84-473

Identification of Primary Flight Control System Characteristics from Dynamic Measurements

J.G. Denhollander

Dept. of Aerospace Engrg., Technische Hogeschool, Delft, The Netherlands, Rept. No. VTH-LR-348, 79 pp (Nov 1982)
N83-28003

Key Words: Aircraft, Parameter identification technique

A method which formulates an a priori mathematical model of the primary flight control system is presented. The model is formulated in a format directly applicable to the analysis of in flight measurements of the motion of the control system relative to the moving aircraft. The model parameters relating the linear and nonlinear model characteristics are extracted from the measurements using multiple regression analysis.

84-474

Pressure Measurements on Twin Vertical Tails in Buffeting Flow

W.E. Triplett

McDonnell Aircraft Co., St. Louis, MO, J. Aircraft, 20 (11), pp 920-925 (Nov 1983) 16 figs, 2 refs

Key Words: Aircraft, Aerodynamic loads, Fluid-induced excitation, Wind tunnel testing

Buffeting pressures were measured on the vertical tail surfaces of a 13% F-15 model in a low-speed wind tunnel. Test variables included dynamic pressure, aircraft angle of attack, vertical tail incidence, and rudder deflection. Pressure transducers were flush mounted on rigid and flexible tails.

84-475

Probabilistic Fracture Mechanics Analysis Methods for Structural Durability

J.L. Rudd, J.N. Yang, S.D. Manning, and B.G.W. Yee

General Dynamics, Fort Worth, TX, 23 pp (Apr 1983) (Behaviour of Short Cracks in Airframe Components, Conf. Proc. Mtg. AGARD Struc. Matls. Panel (55th), Toronto, Canada, Sept 19-24, 1982) AD-A131 159, pp 10-1 - 10-20
AD-P001 608

Key Words: Aircraft, Fracture properties, Probability theory

The requirement for the design of durable Air Force aircraft necessitates an analytical demonstration that excessive cracking within the airframe will not occur during the aircraft's design service life. In order to predict the time at which excessive cracking occurs, an analysis has been developed which is capable of predicting the distribution of crack sizes within the airframe at any point in time. The durability analysis is based on a fracture mechanics philosophy, combining a probabilistic format with a deterministic crack growth rate relationship. Essential elements of the methodology are presented, with emphasis on the statistical representation of the initial fatigue quality of the structure.

84-476

Aircraft Fatigue - with Particular Emphasis on Australian Operations and Research

J.Y. Mann

Aeronautical Res. Labs., Melbourne, Australia, Rept. No. ARL/STRUC-TM-361, 91 pp (Apr 1983)

AD-A131 036

Key Words: Aircraft, Fatigue life, Reviews

This paper traces the history of aircraft structural fatigue until the establishment of the Aeronautical Research Laboratories in 1939, and then deals more specifically with Australian contributions in research and development from then until the present time. These reflect both the lead-the-fleet situation for civil aircraft within Australia and the desire to operate some military aircraft for lives well in excess of their original design lives.

84-477

Correlation of Experimental and Quasi-3D Theoretical Airloads on the Oscillating LANN Supercritical Wing Model

A. Steiginga and H. Houwink

Natl. Aerospace Lab., Amsterdam, The Netherlands, Rept. No. NLR-TR-83003-U, AFWAL-TR-83-3050, 65 pp (May 1983)

AD-A130 550

Key Words: Aircraft wings, Vibration measurement

Correlation of theoretical and experimental unsteady airloads on an oscillating semi-span model of a transport-type supercritical wing (LANN Model) was conducted. The theoretical method is a quasi-3D method which combines 2D transonic small perturbation theory (LTRAN-NLR code) with 2D and 3D subsonic theory (Doublet-Lattice method). Parameters in this correlation are Mach number, frequency, mean angle of attack, and oscillation amplitude.

84-478

Unsteady Transonic Pressure Measurements on a Semi-Span Wind Tunnel Model of a Transport-Type Supercritical Wing (LANN) Lockheed-Georgia, Air Force, NASA, and NLR Model. Part 2. Pressure Distributions (PLOTTED) and Plots of the Vibration Modes

J.J. Hortsen, R.G. den Boer, and R.J. Zwaan

Natl. Aerospace Lab., Amsterdam, The Netherlands, Rept. No. NLR-TR-82069-U-PT-2, AFWAL-TR-83-3030-PT-2, 187 pp (Mar 1983)

AD-A130 488

Key Words: Aircraft wings, Vibration measurement

Unsteady transonic pressure measurements are performed on a semi-span wind-tunnel model of a transport-type supercritical wing, oscillating in pitch. For each run, the vibration mode and detailed steady and unsteady pressure distributions are measured. Sectional as well as wing aerodynamic coefficients are obtained by integration of the pressure distributions.

84-479

Experiences in the Use of Composite Material for a Wing Skin

C.V. Eckstrom and C.V. Spain

NASA Langley Res. Ctr., Hampton, VA, J. Aircraft, 20 (11), pp 913-919 (Nov 1983) 19 figs, 15 refs

Key Words: Aircraft wings, Composite materials, Flutter

Experiences in using composite skin material on an aeroelastic research wing used in flight flutter testing are described. Design and modeling considerations for future applictions are discussed.

84-480

Crashworthiness: An Illustrated Commentary on Occupant Survival in General Aviation Accidents

W.R. Kirkham, S.M. Wicks, and D.L. Lowrey

Civil Aeromedical Inst., Oklahoma City, OK, Rept. No. FAA-AM-83-8, 41 pp (Apr 1983)

AD-A130 198

Key Words: Crash research (aircraft), Crashworthiness

This report is an illustrated commentary on crash survival in general aviation aircraft. Photographs, drawings, and discussion present some basic concepts of crash forces; mechanisms of injury to occupants; and the roles of shoulder harnesses, lapbelts, and seats in attenuating crash forces. Findings in a number of accidents relate seats and restraints to the fate of the occupants.

84-481
Structural Response of Transport Airplanes in Crash Situations
R.G. Thomson and C. Caiafa
NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-85654, 99 pp (June 1983)
N83-27980

Key Words: Crash research (aircraft), Crashworthiness

Results of contractural studies of transport accident data undertaken in a joint research program are highlighted. From these accident data studies it was concluded that the greatest potential for improved transport crashworthiness is in the reduction of fire related fatalities. Accident data pertaining to fuselage integrity, main landing gear collapse, fuel tank rupture, wing breaks, tearing of tank lower surfaces, and engine pod scrubbing are discussed.

MISSILES AND SPACECRAFT

(Also see Nos. 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 560, 561)

84-482
Vibration Measurement and Attenuation for Spacelab Experiments of the D1 Mission
W. Knabe, D. Eilers, H.R. Meyer-piening, and F. Hock
ERNO Raumfahrtechnik GmbH, Bremen, Germany, Rept. No. BMFT-FB-W-83-003, ISSN-0170-1339, 105 pp (Apr 1983)
N83-29301
(In German)

Key Words: Spacecraft, Vibration measurement, Vibration control

G-jitter spectral measurements results taken in the Spacelab engineering model (EM *)/long module configuration are presented, for the frequency band 1 Hz to 200 Hz. The acceleration response of D1 experiment locations within and at the base of the EM-1 long module was determined for full operation as well as for discrete partial operation modes of Spacelab. Responses to additional excitations corresponding to, or simulating, simple or typical forms of astronaut activity were analyzed.

BIOLOGICAL SYSTEMS

HUMAN

84-483
Laboratory Study of the Influence of Noise Level and Vehicle Number on Annoyance
G. Labiale
Institut de Recherche des Transports, Centre d'Evaluation et de Recherche des Nuisances et de l'Energie, 69500 Bron, France, J. Sound Vib., 90 (3), pp 361-371 (Oct 8, 1983) 5 figs, 5 tables, 10 refs

Key Words: Traffic noise, Human response

A laboratory study has been carried out to examine the relationships between annoyance and the level of road noise made up of background noise with emergent noisy truck passages. The annoyance caused to test persons was examined in experimental situations for periods of 30 minutes.

84-484
Biodynamic Response of the Human Body in the Sitting Position When Subjected to Vertical Vibration
P.M. Donati and C. Bonthoux
Laboratoire d'Energetique et de Mechanique Theorique Appliquee, Institut National Polytechnique de Lorraine, 54000 Nancy, France, J. Sound Vib., 90 (3), pp 423-442 (Oct 8, 1983) 12 figs, 4 tables, 12 refs

Key Words: Vibration excitation, Human response

Previous studies of the location of those areas in which the sensation of vibration is perceived under whole body vertical vibration have underlined the predominance of the relative movement between thorax and pelvis. Experiments were designed to explore systematically the transmissibility between the pelvis and thorax. These were supplemented by measurements of mechanical impedance of the body and absorbed power. To determine the body impedance, a procedure was developed to remove the effect of the load platform itself. Fifteen subjects were presented first with

a swept sinusoidal vibration, and then with a broad band random vibration, to see how the wave form of the motion might affect the mechanical response of the body.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see No. 533)

84-485

Identification of Linearized Squeeze-Film Dynamics Using Synchronous Excitation

R. Stanway

Dept. of Mech. Engrg., Univ. of Liverpool, UK, IMechE, Proc., 197, Pt. C, pp 199-204 (Sept 1983) 3 figs, 1 table, 7 refs

Key Words: Isolators, Parameter identification technique, Damping coefficients, Squeeze film dampers

It is demonstrated how the four damping coefficients associated with a squeeze-film isolator can be identified from time-series records of the displacement responses to synchronous excitation.

84-486

Performance of Small Jet Noise Silencers for Industrial Applications

M. Dahl

Dept. of Mech. Engrg., Pennsylvania State Univ., University Park, PA, Rept. No. OSHA/RP-83/007, 142 pp (Apr 1983)
PB83-234047

Key Words: Silencers, Pipes (tubes)

Commercially available small jet noise silencers were tested to determine their noise and mass flow reducing characteristics compared to an open pipe. Both exhaust silencers and ejector silencers were measured for sound power level and mass flow rate. In addition, the pressure patterns developed on a flat plate by the air flow from the ejector silencers were measured.

84-487

Possibilities of Application of Vibration Absorbers to Self-Excited Rotor Systems (Anwendungsmöglichkeiten von Schwingungsdämpfern in selbsterregten Rotorsystemen)

A. Tondl

Z. angew. Math. Mech., 63 (9), pp 425-431 (1983) 9 figs, 10 refs
(In German)

Key Words: Absorbers (equipment), Dynamic vibration absorption (equipment), Rotors

A study on the possibility of using tuned absorbers in self-excited rotor systems having vertical axis of rotation is presented. It is shown that not every application of the absorber brings the desired result.

84-488

Evaluation of Viscoelastic Coatings as Low Frequency Acoustic Absorbers

Yie-Ming Chen and R.L. Gran

Dynamics Technology, Inc., Torrance, CA, Rept. No. DTN-8265-01, 68 pp (May 1983)
AD-A130 346

Key Words: Acoustic absorption, Elastomers, Underwater structures

This study examines the effectiveness of elastomer coatings for specular, acoustic backscatter reduction in low frequency, under-water applications. Four representative elastomers were selected: Butyl B252, Neoprene W, Polybutadiene, and thiokol RD. Their coating reflection loss for CW and impulse incident acoustic plane waves was examined using techniques and computer codes developed based on a geometric acoustics approach.

84-489

Development of Monofilar Rotor Hub Vibration Absorber

J. Duh and W. Miao

Sikorsky Aircraft Div., United Technologies Corp., Stratford, CT, Rept. No. NASA-CR-166088, 91 pp (May 1983)
N83-29272

Key Words: Vibration absorption (equipment), Helicopters

A design and ground test program was conducted to study the performance of the monofilar absorber for vibration reduction on a four-bladed helicopter. A monofilar is a centrifugal tuned two degree-of-freedom rotor hub absorber that provides force attenuation at two frequencies using the same dynamic mass. Linear and nonlinear analyses of the coupled monofilar/airframe system were developed to study tuning and attenuation characteristics. Based on the analysis, a design was fabricated and impact bench tests verified the calculated nonrotating natural frequencies and mode shapes.

A model consisting of n five-degree-of-freedom subsystems has been developed to characterize some of the mechanical response features of a bladed disk system, including four modes of each blade, n bending modes of the disk, blade-to-blade and blade-to-ground Coulomb friction, structural damping, blade-to-blade mistuning, and various types of excitation. The equations of motion and method of solution are described, and numerical results illustrate some of the interesting effects of various levels of frictional damping on tuned and mistuned systems.

BLADES

(Also see No. 433)

84-490

Natural Frequencies of Rotating Bladed Disks Using Clamped-Free Blade Modes

S.J. Wildheim

Stal-Laval Turbin AB, Finspang, Sweden, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 416-424 (Oct 1983) 7 figs, 1 table, 16 refs

Key Words: Blades, Disks, Natural frequencies, Substructuring methods

The problem of calculating the natural frequencies of a practical rotating bladed disk assembly is solved by use of a new dynamic substructuring method employing the free modes of the disk and the clamped-free modes of the blade. The bladed disk may have lacing-wires at any radius. The lacing-wire, or any other general elastic connection element, is assumed to extend around the whole circumference. Hence, the assembly fulfills the requirements for a circumferentially periodic structure. Centrifugal effects are included.

84-491

A Parametric Study of Dynamic Response of a Discrete Model of Turbomachinery Bladed Disk

A. Muszyńska and D.I.G. Jones

Bently-Nevada Corp., Minden, NV, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 434-443 (Oct 1983) 19 figs, 1 table, 8 refs

Key Words: Blades, Disks, Turbomachinery blades, Coulomb friction, Tuning

84-492

Aeroelastic Characteristics of a Cascade of Mistuned Blades in Subsonic and Supersonic Flows

R.E. Kielb and K.R.V. Kaza

NASA Lewis Res. Ctr., Cleveland, OH, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 425-433 (Oct 1983) 14 figs, 19 refs

Key Words: Blades, Cascades, Flutter, Forced vibration, Tuning

An investigation of the effects of mistuning on flutter and forced response of a cascade in subsonic and supersonic flows is presented. The aerodynamic and structural coupling between the bending and torsional motions and the aerodynamic coupling between the blades are included. It is shown that frequency mistuning always has a beneficial effect on flutter.

84-493

Tensile Buckling of Advanced Turboprops

C.C. Chamis and R.A. Aiello

NASA Lewis Res. Ctr., Cleveland, OH, J. Aircraft, 20 (11), pp 907-912 (Nov 1983) 10 figs, 4 tables, 8 refs

Key Words: Blades, Propeller blades, Buckling, Resonant frequencies

Theoretical studies were conducted to determine analytically the tensile buckling of advanced propeller blades (turboprops) in centrifugal fields, as well as the effects of tensile buckling on resonant frequencies. Theoretical studies were also conducted to establish the advantages of using high-performance composite turboprops as compared to titanium.

84-494

Determination of Vibration Amplitudes and Stresses Using the Holography Interference Techniques and Finite Element Method

Z.F. Fu

Vibration Shock and Noise Lab., Shanghai Jiao Tong Univ., Shanghai, People's Rep. of China, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 484-488 (Oct 1983) 6 figs, 1 table, 5 refs

Key Words: Blades, Compressor blades, Turbine blades, Amplitude analysis, Holographic techniques

A new method which combines the holography interference technique with the finite element method for determining the distribution of vibration amplitudes and stresses of gas turbine compressor blades is presented. In comparison with the ordinary electrical strain gage method, the present method has the advantage that there is no limitation to the number of measuring points and good results can be obtained even at high order modes.

84-495

Unsteady Pressure on a Cambered Blade under Periodic Gusts (Comparison with the Experiments)

Y. Murakami, T. Hirose, T. Adachi, and M. Ishikawa

Osaka Univ., 1-1, Machikaneyama-cho, Toyonaka, Osaka, 560, Japan, Bull. JSME, 26 (218), pp 1315-1322 (Aug 1983) 14 figs, 8 refs

Key Words: Blades, Wind-induced excitation

An experimental investigation was conducted to clarify the validity and the limitations of the analytic predictions of an unsteady pressure on a blade under periodic gusts. The unsteady pressure distributions around both cambered and symmetrical blades with angle of attack were measured. The results were compared with the theoretical ones considering the effects of angle of attack and camber.

BEARINGS

84-496

Seismic Analysis of a Gyroscopic Mechanical System

A.H. Soni and V. Srinivasan

School of Mech. and Aerospace Engrg., Oklahoma State Univ., Stillwater, OK 74078, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 449-454 (Oct 1983) 8 figs, 3 tables, 16 refs

Key Words: Bearings, Fluid-film bearings, Seismic analysis, Coriolis forces, Gyroscopic effects, Stiffness effects, Damping effects

The dynamic analysis of a gyroscopic mechanical system subjected to seismic excitation is presented. The gyroscopic system consists of a rigid rotor mounted on fluid film bearings. The seismic excitation subjects the base to translational as well as rotational motion. The analysis includes gyroscopic effects, Coriolis effects due to base rotation, and the stiffness and damping provided by the fluid film bearings. A numerical example is solved to show the importance of including the base rotation in the analysis.

84-497

Static and Dynamic Properties of Oil Films in Displaced Centres Elliptical Bearings

A. Singh and B.K. Gupta

Motilal Nehru Regional Engrg. College, Allahabad, India, IMechE, Proc., 197, Pt. C, pp 159-165 (Sept 1983) 12 figs, 1 table, 17 refs

Key Words: Bearings, Journal bearings

The possibility of improving the stability of elliptical bearings by displacing the lobe centers has received little attention. The effect of displacing the lobe centers on the load capacity, attitude angle and on elastic and damping coefficients is examined.

84-498

Normal Vibration of a Plain Bearing Working under Boundary Lubrication Conditions

G.P. Massouros

School of Engrg., Univ. of Patras, Patras, Greece, Trib. Intl., 16 (5), pp 235-238 (Oct 1983) 9 figs, 4 refs

Key Words: Bearings

During sliding in a plain-bearing system under boundary lubrication conditions, the impact of the existing micro-asperities causes the system to vibrate. The resulting spectrum depends, among other things, on the type of material and the micro- and macrogeometries of the sliding surfaces. Running-in of plain bearings can be monitored by studying the changes in the respective spectra of vibrations.

84-499

Transverse Roughness in Short Journal Bearings under Dynamic Loading

A. Raj and P. Sinha
Dept. of Mathematics, Indian Inst. of Tech. Kanpur, Kanpur 208016, India, Trib. Intl., 16 (5), pp 245-251 (Oct 1983) 7 figs, 2 tables, 9 refs

Key Words: Bearings, Surface roughness, Lubrication, Periodic excitation

The stochastic theory developed by Christensen is applied to the analysis of dynamically loaded short rough bearings which have striations transverse to the direction of motion. An approximate polynomial is used, in place of a Gaussian function, to represent the roughness profile. To make the analysis applicable to real lubrication situations, it is assumed that the standard deviation of the roughness height and the minimum film thickness are of the same order. Attention is focused on the cyclic squeeze films under sinusoidal loading.

84-500

Gas Bearings. Part 1: Dynamic Analysis and Solution Method

M. Chandra, M. Malik, and R. Sinhasan
Dept. of Mech. and Indus. Engrg., Univ. of Roorkee, Roorkee 247667, India, Wear, 88 (3), pp 255-268 (July 15, 1983) 1 fig, 1 table, 20 refs

Key Words: Bearings, Gas bearings

A state-of-the-art review of gas bearing analyses is given. A dynamic analysis and solution scheme are presented to obtain the performance characteristics of gas-lubricated bearings. The scheme gives excellent results over the entire operating range.

84-501

Theoretical Analysis of the Dynamic Stiffness of Conical Hydrostatic Thrust Bearings under Tilt, Eccentricity and Rotation

T.J. Prabhu and N. Ganesan
Dept. of Appl. Mechanics, Indian Inst. of Tech., Madras 600036, India, Wear, 91 (2), pp 149-159 (Nov 1, 1983) 11 figs, 13 refs

Key Words: Bearings, Hydrostatic bearings, Dynamic stiffness

A theoretical study of the dynamic stiffness characteristics of capillary compensated annular recess conical hydrostatic thrust bearings under conditions of tilt, eccentricity and rotation is reported. The influences of aspect ratios, cone angles and resistance ratios on the dynamic stiffness are discussed.

GEARS

84-502

Vibration in Planetary Gear Systems with Unequal Planet Stiffnesses

J.L. Frater, R. August, and F.B. Oswald
NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. E-1716, NASA-TM-83428, 16 pp (1982)
N83-29709

Key Words: Gears, Planet gears, Natural frequencies, Mode shapes

An algorithm suitable for a minicomputer was developed for finding the natural frequencies and mode shapes of a planetary gear system which has unequal stiffnesses between the sun/planet and planet/ring gear meshes. Mode shapes are represented in the form of graphical computer output that illustrates the lateral and rotational motion of the three coaxial gears and the planet gears. This procedure permits the analysis of gear trains utilizing nonuniform mesh conditions and user specified masses, stiffnesses, and boundary conditions.

84-503

Dynamic Effects of Internal Spur Gear Drives

A. Pintz, R. Kasuba, J.L. Frater, and R. August
Cleveland State Univ., OH, Rept. No. NASA-CR-3692, 286 pp (June 1983)
N83-28452

Key Words: Gears, Spur gears, Computer programs

Static analysis, dynamic analysis, and computer programs are discussed. Spur gear formulae and involute profile development and deflection are also discussed.

FASTENERS

84-504
Wave Transmission and Energy Dissipation at Structural and Machine Joints
L. Gaul
Univ. of the German Armed Forces, Hamburg, Fed. Rep. Germany, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 489-496 (Oct 1983) 9 figs, 1 table, 12 refs

Key Words: Joints (junctions), Riveted joints, Bolted joints, Compression joints, Wave transmission, Wave reflection, Energy dissipation

The dynamics of composed structures is influenced by the transfer behavior of interfaces of bolted, riveted, and compression joints. The measured nonlinear behavior of such joints is represented by equivalent linearized models and coupled with models of the members. Excitations by incident flexural waves, as well as longitudinal waves, are discussed. Characteristics of wave transmission, wave reflection, and energy dissipation of jointed beams are calculated. The influence of different models of joints is compared and a test setup for experimental verification is proposed.

VALVES

84-505
The Industrial Detection and Evaluation of Control Valve Cavitation
M.L. Riveland
Fisher Controls International, Inc.
ISA Trans., 22 (3), pp 71-80 (1983) 8 figs, 1 table, 11 refs

Key Words: Valves, Cavitation, Prediction techniques

As control valve designs change to meet the needs of the arduous service market, new methods of evaluating product performance are required. This paper presents two methods of evaluating the onset and nature of cavitation in control valves. The first method utilizes pipe-wall vibrations in a select frequency range to provide a consistent means of determining the incipient cavitation point. The second method employs a cavitation-sensitive coating to indicate the presence of cavitation attack on a given flow surface.

STRUCTURAL COMPONENTS

BARS AND RODS

84-506
Dynamic Formulation of Heterogeneous Rectangular Section Rod (Formulation dynamique des tiges hétérogènes à section rectangulaire)
M. Touratier
Laboratoire de Structures, E.N.S.A.M., 151, boulevard de l'hopital, 75640 Paris Cedex 13, France, J. de Mécanique Théor. Appl., 2 (3), pp 307-324 (1983) 9 refs
(In French)

Key Words: Rods, Multibeam systems

A dynamic formulation destined for rectangular cross-section heterogeneous rods is proposed. The rod is composed of nine homogeneous rods of rectangular section and different orthotropic materials. The model is constructed from basic elements and uses a variational method (stress and displacements) with a view to satisfying interface continuity conditions for the basic elements, and boundary conditions for the heterogeneous rod.

BEAMS

(Also see No. 565)

84-507
On a Finite Element Formulation of Dynamical Torsion of Beams Including Warping Inertia and Shear Deformation Due to Nonuniform Warping
A. Potiron and D. Gay
Dept. of Mechanics, INSA, 31077 Toulouse, France, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 476-484 (Oct 1983) 4 figs, 7 refs

Key Words: Beams, Torsional response, Warping, Transverse shear deformation effects

The energetic expressions of dynamical torsion of beams in terms of angular and warping displacement and velocity are discussed. The stiffness and two mass matrices including both secondary effects for torsion, the shear deformation due to nonuniform warping and the warping inertia, are

derived. The suitability of these matrices for evaluation modified torsional frequencies is investigated in the case of thick, as well as thin-walled, cross section beams by comparison with analytical and experimental results.

tion of this problem on the basis of Von Karman's equations and to propose a method of solution in the case of forced vibrations. It is based on the Krylov-Bogoliubov linearization method and on the notion of nonlinear modes.

84-508

Vibration of Bimodular Sandwich Beams with Thick Facings: A New Theory and Experimental Results

C.A. Rebello, C.W. Bert, and F. Gordaninejad
School of Aerospace, Mech. and Nucl. Engrg., Univ. of Oklahoma, Norman, OK 73019, J. Sound Vib., 90 (3), pp 381-397 (Oct 8, 1983) 8 figs, 3 tables, 21 refs

Key Words: Beams, Sandwich structures, Bimodular properties, Vibration analysis, Transverse shear deformation effects

This study deals with both analytical and experimental investigations of three-layer beams with cores of polyurethane foam and facings of unidirectional cord-rubber. Both of these materials are bimodular (i.e., having different behavior in compression as compared to tension). The new theory presented is a shear-flexible laminate version of the well-known Timoshenko beam theory, which, due to the bending-stretching coupling present in the bimodular case, results in a coupled sixth-order system of differential equations. In this theory, a separate derivation is presented for the shear correction factor.

PLATES

(Also see No. 573)

84-509

Structural Damping by Slip in Joints

L. Jezequel
Dept. of Mech. Engrg., Ecole Centrale de Lyon, 69130 Ecully, France, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 497-504 (Oct 1983) 8 figs, 22 refs

Key Words: Plates, Joints (junctions), Bolted joints, Riveted joints, Harmonic excitation, Structural damping

The analysis of slip in riveted or bolted joints during harmonic excitation has been the subject of much research. However, in the case of plates the slip is induced by in-plane forces which do not appear in the classical linear plate theory. The aim of this study is to present a general formulation of this problem on the basis of Von Karman's equations and to propose a method of solution in the case of forced vibrations. It is based on the Krylov-Bogoliubov linearization method and on the notion of nonlinear modes.

84-510

Dynamics of Coupled Fluid-Structure Multiplate Systems

K.R. Aggarwal, R. Sinhasan, and G.K. Grover
Punjab Engrg. College, Chandigarh, 160 012, India, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 505-511 (Oct 1983) 5 figs, 3 tables, 19 refs

Key Words: Interaction: structure-fluid, Plates, Submerged structures

A general formulation, for the study of free vibrations and frequency response of a multiplate system fully submerged in fluid contained in an enclosure, is presented. The present study is carried out for two-plate systems only.

84-511

Convergence of Modal Series in a Plate Struck by a Shock Wave

R.S. Schechter and R.L. Bort
Naval Res. Lab., Washington, DC, Rept. No. NRL-MR-5142, 43 pp (July 21, 1983)
AD-A130 663

Key Words: Plates, Cantilever plates, Underwater structures, Shock waves, Interaction: structure-fluid

Numerical calculations are shown for a simplified model of a plate subjected to a pressure pulse and a base motion while immersed in an acoustic fluid.

SHELLS

84-512

Effects of Uni-Directional Geometric Imperfections on Vibrations of Pressurized Shallow Spherical Shells

D. Hui and A.W. Leissa
Dept of Engrg. Mechanics, Ohio State Univ., Colum-

bus, OH 43210, Intl. J. Nonlin. Mech., 18 (4), pp 279-285 (1983) 4 figs, 13 refs

Key Words: Shells, Spherical shells, Geometric imperfection effects, Natural frequencies

This paper deals with the effects of initial geometric unidirectional imperfections on vibrations of a pressurized spherical shell or spherical cap. The analysis is based upon shallow shell theory. Frequency vs applied pressure interaction curves are plotted for various values of the imperfection amplitude.

84-513

Fluid Dynamic Experiment in a Surface Tension Tank: Phase 1/Phase 2A

G. Netter and K. Eckhardt

ERNO Raumfahrtechnik GmbH, Bremen, Germany, Rept. No. BMFT-FB-W-83-002, ISSN-0170-1339, 26 pp (Apr 1983)

N83-29649

(In German)

Key Words: Tanks (containers), Sloshing, Space shuttles, Spacecraft components

A space shuttle tank/fluid dynamic experiment is described. The experiment determines the low g fluid dynamic effects as a reaction due to excitation. The dynamic parameters of a fluid/tank system are evaluated. In parallel, analytical investigations result in the form of an equivalent mechanical model. The experimental data, obtained using a small diameter tank, were compared to the predictions of the mechanical model.

PIPES AND TUBES

(Also see Nos. 455, 486)

84-514

Two-Hydrophone Technique for Measuring the Complex Reflectivity of Materials in Water-Filled Tubes

S.S. Corbett, III

Applied Res. Lab., Pennsylvania State Univ., State College, PA, Rept. No. ARL/PSU/TM-82-246, 158 pp (Sept 27, 1982)

AD-A130 613

Key Words: Tubes, Fluid-filled containers, Acoustic impedance, Measurement techniques, Two microphone technique

A two-microphone technique was developed for measuring the complex reflection factor, and through it the complex acoustic impedance, of a material surface in tubes containing air. The procedure consists of simultaneously sampling the stationary acoustic field at two locations in front of an *ensonified sample*. This thesis describes an extension of this technique to measure the same characteristics in water-filled tubes. A number of modifications were needed in order to implement the technique. These included the development of a two-hydrophone system that did not perturb the acoustic field and yet was isolated from any structure-borne noise, and the development of more elaborate signal processing procedures in which pulses of sound rather than a continuous sound field were projected to ensonify the tube.

84-515

Structure-Borne Sound Transfer Functions of a Compound Flexible Pipe Connection with a 90 Degree Bend

B. Vandergraaf

Technisch Physische Dienst TNO-TH, Delft, The Netherlands, Rept. No. TDCK-77328, 25 pp (Sept 1, 1982)

N83-28464

Key Words: Pipes (tubes), Bellows, Structure-borne noise

The sound transfer functions of a compound flexible pipe connection with a 90 degree bend were determined using an excitation mass and a seating mass of 20 Kg, and water or air filled bellows. The connection is used for the resiliently mounted diesel engines aboard a minehunter. The results are given as function of the excitation frequency of up to 1 KHz.

84-516

Finite Element Analysis for Evaluation of Eigenfrequency and Natural Shape Alterations by Welded Joint Cracks for Pipes of Offshore-Platforms

R. Dietrich

GKSS - Forschungszentrum Geesthacht GmbH, Geesthacht-Tesperhude, Fed. Rep. Germany, Rept. No. GKSS-82/E/10, 34 pp (1982)

DE83750055

(In German)

Key Words: Pipes (tubes), Off-shore structures, Drilling platforms, Welded joints, Natural frequencies, Mode shapes

In this report an analysis is presented for the alteration of frequencies and natural shapes of vibration for a pipe of an offshore structure by different welded joint cracks. The analysis is performed using the finite element method. The basic concepts of this method are explained. The eight lowest frequencies are stated for different welded joint cracks. For these frequencies the natural shapes of vibration are demonstrated in three-dimensional form.

84-517

Vibrations Induced by Fluid Flow in Piping Systems (TEDEL FLUIDE Code)

F. Axisa

CEA Centre d'Etudes Nucleaires de Saclay, Gif-sur-Yvette, France, Rept. No. CEA-CONF-6287, CONF-8206139-2, 219 pp (June 1982) (Pres. at Mtg. on Dynamics of Mech. Structures and Equipments, Paris, France, June 8, 1982)

DE83700847

(In French)

Key Words: Piping systems, Fluid-induced excitation, Computer programs

The dynamic behavior of pipes has been the subject of several studies involving the different aspects of the problem (dense fluid, flow with random pressure fluctuations, pressure waves, flexible piping). Studies made include: the development of a finite elements calculation code: TEDEL FLUIDE; an experimental work on the validation of the TEDEL code and on the characterization of random pressure sources generated by the flows. An overall view of the various problems dealt with is presented, completed by a set of documents in which each specific subject is treated in detail.

BUILDING COMPONENTS

84-518

Parameter Sensitivity of a T-Junction Sea Model; the Importance of the Internal Damping Loss Factors

J.G. van Bakel and D. De Vries

Dept. of Applied Physics, Delft Univ. of Tech., 2600 GA Delft, The Netherlands, J. Sound Vib., 90 (3), pp 373-380 (Oct 8, 1983) 6 figs, 10 refs

Key Words: Buildings, Walls, Internal damping, Statistical energy analysis

For a typical building acoustics configuration, a T-junction of plates formed by a light weight wall placed on a heavy floor, a statistical energy analysis (SEA) model is presented. Only structural systems (i.e., no acoustic wavefields) are considered. Besides bending waves also in-plane waves, quasi-longitudinal and plane transverse waves are included in the calculation. A parametric survey is conducted on the T-junction model -- for one frequency (1000 Hz) only -- in order to find the sensitivity of the SEA model to the inaccuracies of its parameters.

ELECTRIC COMPONENTS

CONTROLS

(Switches, Circuit Breakers)

84-519

Robust Controller Design for Linear Dynamic Systems Using Approximate Models

D.H. Owens and A. Chotai

Dept. of Control Engrg., Sheffield Univ., UK, Rept. No. RR-194, 47 pp (July 1982)

N83-28964

Key Words: Control systems, Design techniques, Frequency domain method

Frequency-domain design techniques are extended to incorporate information deduced from the observed differences between open-loop plant and approximate model step response to quantify the uncertainty and, in particular, to guarantee closed-loop stability and tracking of step demands. A modification of this analysis uses time-domain data, leading to a simple simulation method for assessing stability that avoids the need for complex frequency domain calculations.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 462, 514, 515, 577)

84-520

P Waves Transient Scattering by 2-D Penetrable Targets: A Direct Solution

D. Lesselier

Groupe d'Electromagnetisme, Laboratoire des Signaux et Systèmes, Plateau du Moulon, 91190, Gif sur Yvette, France, J. Acoust. Soc. Amer., 74 (4), pp 1274-1278 (Oct 1983) 7 figs, 6 refs

Key Words: Acoustic scattering, Sound waves, Wave scattering, Time domain method

The scattering of a transient acoustic P wave by a two-dimensional inhomogeneous fluid target is studied. An exact time-domain formulation of the pressure is introduced and discretized. Discrete pressures are then computed by marching on in time and space. The convergence of this step by step procedure is examined numerically.

84-521

Resonant Acoustic Scattering from Elastic Cylindrical Shells

E.D. Breitenbach, H. Uberall, and Kwang-Bock Yoo

Catholic Univ., Washington, DC 20064, J. Acoust. Soc. Amer., 74 (4), pp 1267-1273 (Oct 1983) 11 figs, 9 refs

Key Words: Acoustic scattering, Sound waves, Wave scattering, Underwater sound, Submerged structures, Cylindrical shells

The normal mode solution ofthe scattered pressure due to a normally incident plane acoustic wave on an infinitely long, air-filled aluminum cylindrical shell in water is analyzed. The study yields a physical interpretation of normal mode contributions to the backscattering function. The modes in the near-soft (thin-shell) region are compared to theoretical predictions and empirical observations.

84-522

A Technique for the Prediction of the Noise Field from an Arbitrary Vibrating Machine

D.C. Hodgson and M.M. Sadek

Dept. of Mech. Engrg., Univ. of Birmingham, UK, IMechE, Proc., 197, Pt. C, pp 189-197 (Sept 1983) 10 figs, 16 refs

Key Words: Vibrating structures, Noise generation, Noise prediction, Computer-aided techniques, Finite element technique, Helmholtz integral method

A comprehensive computer aided design package has been developed to predict the sound field and sound power of an arbitrary vibrating machine structure subject only to the limitations of computer storage. The technique is a combination of a standard finite element package and a specially developed noise prediction package based on the Helmholtz integral equation. The accuracy of the package has been verified experimentally for two impact forming machines.

SHOCK EXCITATION

(Also see Nos. 442, 443, 444, 445, 446, 447, 448, 449, 511, 560, 561, 572)

84-523

Lateral-Torsional Response of Structures Subjected to Seismic Waves

S.T. Wu and E.V. Leyendecker

Natl. Engrg. Lab., Natl. Bureau of Standards, Washington. DC, Rept. No. NBSIR-83-2727, 32 pp (June 1983)

PB83-239582

Key Words: Torsional response, Seismic excitation

The behavior of coupled lateral-torsional systems subjected to seismic waves is investigated analytically. The report presents the numerical results of a parametric study for structures subjected to S-H waves. Case studies are provided to show the contribution of each of the selected parameters to the rotational response of the systems. These parameters are: geometric eccentricity, aspect-ratio of the foundation mat, damping ratio, and the ratio of the rotational to translational frequencies.

84-524

On Upstream Influence in Shock Wave Turbulent Boundary Layer Interaction

D.S. Dolling

Mech. and Aerospace Engrg. Dept., Princeton Univ., NJ, Aeronaut. J., 87 (868), pp 324-327 (Oct 1983) 5 figs, 11 refs

Key Words: Shock wave propagation

In shock wave turbulent boundary layer interaction, upstream influence is defined as the distance from the inviscid shock wave to where the incoming boundary layer is first disturbed. The latter position is generally taken as being where the mean wall pressure first increases above the undisturbed value. Wall pressure fluctuation measurements in two Mach 3, high Reynolds number interactions have shown that unsteadiness of the separation shock wave structure results in the instantaneous upstream influence varying over a range of values.

84-525

Simulation of a Nuclear Blast Wave with a Gaseous Detonation Tube

A.L. Kuhl

R and D Associates, Marina del Rey, CA, Rept. No. RDA-TR-125004-003, DNA-TR-83-06, 34 pp (Mar 1, 1983)

AD-A131 489

Key Words: Nuclear weapons effects, Shock wave propagation, Shock tube testing

There is an ongoing interest in simulating nonideal blast environments for nuclear effects research; i.e., imposing peaked blast waves on real ground surfaces and experimentally measuring the ensuing dusty airblast environment. Proposed here is a gaseous detonation tube blast simulator.

VIBRATION EXCITATION

(Also see Nos. 495, 578)

84-526

Application of Experimental and Theoretical Vibration Analysis Methods (Anwendung von experimentellen und theoretischen Schwingungsuntersuchungsmethoden)

H. Freund, W. Schilling, and J. Schmied

Fachgebiet Maschinendynamik, T.H. Darmstadt, Germany, Konstruktion, 35 (10), pp 397-401 (Oct 1983) 10 figs, 1 table, 2 refs

(In German)

Key Words: Natural frequencies, Mode shapes, Machinery vibration, Structural modification techniques

The dynamic response of machines can be investigated experimentally and theoretically. In this paper the natural frequencies and mode shapes of a machine are determined by means of experimental modal analysis and the response spectra are measured. Free and forced vibrations, excited by impact, of the same machine were investigated by means of finite element technique and compared with experimental results. The dynamic response data obtained was used in structural modification.

84-527

Procedure for Combining Acoustically Induced and Mechanically Induced Loads (First Passage Failure Design Criterion)

D.R. Crowe and W. Henricks

Lockheed Missiles and Space Co., Inc., Sunnyvale, CA, Rept. No. LMSC/D885405-SS-1633, NASA-CR-166824, 88 pp (Apr 1983)

N83-27795

Key Words: Vibration response, Acoustic excitation, Random excitation

Combined load statistics are developed by taking the acoustically induced load to be a random population, assumed to be stationary. Each element of this ensemble of acoustically induced loads is assumed to have the same power spectral density, obtained previously from a random response analysis employing the given acoustic field in the STS cargo bay as a stationary random excitation. A method is shown for determining the probability that the combined load would, at any time, have a value equal to or less than a certain level. Having obtained a statistical representation of how the acoustic and mechanical loads are expected to combine, an analytical approximation for defining design levels for these loads is presented using the first passage failure criterion.

84-528

Tug Fork River Big Bend Cutoff Blast Monitoring Study

C.E. Joachim

Structures Lab., Army Engineer Waterways Experiment Station, Vicksburg, MS, Rept. No. WES-MP-SL-83-4, 159 pp (Mar 1983)

AD-A130 271

Key Words: Traffic-induced vibrations, Blast excitation, Vibration measurement

This report documents the results of a blast vibration monitoring program. Explosive and traffic (railroad and highway) induced vibration data were measured at selected sites in the vicinity of the proposed excavation.

84-529

The Response and Distribution of Maxima of a Non-Linear Oscillator with Band Limited Excitation

H.G. Davies

Dept. of Mech. Engrg., Univ. of New Brunswick, Fredericton, New Brunswick, Canada, J. Sound Vib., 90 (3), pp 333-339 (Oct 8, 1983) 1 fig, 10 refs

Key Words: Oscillators, Nonlinear springs

The response of an oscillator with a nonlinear spring is considered when the excitation force is white noise filtered through a first order low pass filter. A density function for the distribution of maxima is obtained that covers both narrow band and broad band response. A numerical example of the nonlinear maxima distribution is calculated for the case of an oscillator with a bilinear spring.

84-530

Application of Unsteady Laminar Triple-Deck Theory to Viscous-Inviscid Interactions from an Oscillating Flap in Supersonic and Subsonic Flow

Ming-Ke Huang and G.R. Inger

Univ. of Colorado, Boulder, CO 80309, J. de Mecanique Theor. Appl., 2 (3), pp 325-349 (1983) 10 figs, 17 refs

Key Words: Airfoils

Unsteady triple-deck theory is applied to analyze the local viscous-inviscid interaction of an idealized oscillating flap with a laminar boundary layer in either supersonic or subsonic external flow. For small flap amplitudes and small-to-moderate nondimensional frequencies, linearized analytical solutions by means of Fourier transformation are given for the pressure and shear distributions ahead of and behind the flap hinge.

84-531

Time-Marching Transonic Flutter Solutions Including Angle-of-Attack Effects

J.W. Edwards, R.M. Bennett, W. Whitlow, Jr., and D.A. Seidel

NASA Langley Res. Ctr., Hampton, VA, J. Aircraft, 20 (11), pp 899-906 (Nov 1983) 13 figs, 32 refs

Key Words: Flutter, Airfoils, Computer programs

Transonic aeroelastic solutions based upon the transonic small perturbation potential equation are studied. Time-marching transient solutions of plunging and pitching airfoils are analyzed using a complex exponential modal identification technique. The HYTRAN2 code is used to determine transonic flutter boundaries vs Mach number and angle of attack for NACA 64A010 and MBB A-3 airfoils.

MECHANICAL PROPERTIES

DAMPING

(Also see No. 485)

84-532

Dynamic Damping System

C.F. Grove and D.A. Rodriguez

Dept. of the Air Force, Washington, DC, U.S. Patent Appl. No. 4 387 971, 6 pp (June 14, 1983)

Key Words: Dampers

A dynamic damping system for stabilizing the motion of a large object with respect to inertial space by adding mechanical damping to an angular positioning servo system for the object is described. The mechanical damping is achieved by a dynamic damper assembly which attaches to an inertial balancer that provides inertia feedback to the servo system. The dynamic damper assembly along with the inertia balancer mechanically assist the positioning servo system.

84-533

Squeeze-Film Damping of Rotor-Dynamic Systems

M. Dogan and R. Holmes

School of Engrg. and Applied Sciences, Univ. of

Sussex, Falmer, Brighton, Sussex BN1 9QT, UK, Shock Vib. Dig., 15 (9), pp 3-8 (Sept 1983) 27 refs

Key Words: Squeeze film dampers, Vibration isolators, Reviews

This article is a review of the roles of the squeeze-film damper when used in parallel with a flexible element in a vibration isolator and when used in a series with flexible pedestals or the frame of a rotor-dynamic system.

84-534

Digital Instrumentation Package or an Improved Torsion Pendulum

R.W. Nash and A.E. Schwaneke

Rolla Res. Ctr., Bureau of Mines, Rolla, MO, Rept. No. BUMINES-R1-8774, 15 pp (June 1983) PB83-240424

Key Words: Vibration damping, Measuring instruments, Digital techniques

This report describes the design and operation of a digital instrumentation package for the Bureau of Mines improved *torsion pendulum,* a scientific instrument that measures the vibration damping of metallic materials. The new design eliminates manual analog-to-digital conversion, reduces the data acquisition time, and increases the precision of the measurements. The digital output can be coupled directly to a micro-processor or computer to produce the final data in real time.

FATIGUE

84-535

The Application of a Nonlinear Fracture Mechanics Parameter to Ductile Fatigue Crack Growth

G.A. Hartman, III, A.M. Rajendran, and D.S. Dawicke

Res. Inst., Dayton Univ., Dayton, OH, Rept. No. AFWAL-TR-83-4023, 126 pp (Dec 1982) AD-A130 402

Key Words: Crack propagation, Fatigue life

The methodology for predicting fatigue crack growth rate response of cracked structural components wherein the assumptions of linear elastic fracture mechanics are violated is described. Fatigue crack growth rate tests are conducted on copper specimens using compact tension, centercracked panel, and radial-hole cracked geometries.

84-536

Fatigue Crack Propagation Behavior of Two-Layered Low Carbon Steel-Stainless Steel Composite Plates

T. Tanaka and Y. Fukuchi

Ritsumeikan Univ., Kyoto, Japan, Bull. JSME, 26 (218), pp 1273-1280 (Aug 1983) 12 figs, 2 tables, 15 refs

Key Words: Crack propagation, Fatigue life, Plates, Composite materials, Steel

Fatigue crack propagation tests were conducted on butt-bonded two layered composite plates consisting of a low carbon steel and a ferritic or austenitic stainless steel under pulsating tension varying from zero to maximum, to study the effects of residual thermal stress and the difference in mechanical properties on the crack propagation and crack opening behaviors.

84-537

Size Effect on Rotating Bending Fatigue in Steels

K. Hatanaka, S. Shimizu, and Z. Nagae

Yamaguchi Univ., Ube, 755, Japan, Bull. JSME, 26 (218), pp 1288-1295 (Aug 1983) 16 figs, 4 tables, 18 refs

Key Words: Fatigue tests, Steel

Rotating bending fatigue tests were performed for forged and cast steels on specimen sizes in the range of from 8 to 40 mm in diameter.

84-538

Study of Small Crack Growth under Transport Spectrum Loading

D.Y. Wang

McDonnell Douglas Corp., Long Beach, CA, 15 pp (Apr 1983) Behaviour of Short Cracks in Airframe Components, Conf. Proc. Mtg. AGARD Struc. Matls.

Panel (55th) Toronto, Canada, Sept 19-24, 1982, AD-A131 159, pp 14-1 - 14-15
AD-P001 612

Key Words: Crack propagation, Fatigue tests

This paper describes a study of microcrack growth and statistical fatigue in terms of the initial quality of fastener holes in aluminum alloy. A special test procedure was used to obtain a statistically large sample of data under spectrum loading by testing a specimen containing 24 holes with maximum of 48 fatigue data sets. A total of seven specimens were tested. Small crack measurements were taken by fractography and surface observation.

84-539

Spectrum Effects on the Growth of Short Cracks

B.I. Sandor, D.A. Haas, and T. Ozakat

Univ. of Wisconsin, Madison, WI, 7 pp (Apr 1983) Behaviour of Short Cracks in Airframe Components, Conf. Proc. Mtg. AGARD Struc. Matls. Panel (55th), Toronto, Canada, Sept 19-24, 1982
AD-P001 611

Key Words: Fatigue life, Crack propagation

Several phenomena are discussed concerning creep-fatigue effects on crack initiation and propagation in notched 7075-T651 aluminum at room temperature. Background data show complete creep ruptures of smooth specimens in a time of 10 to the 6th power at stresses about equal to the yield strength.

84-540

Crack Propagation at Short Crack Lengths under Variable Amplitude Loading (2nd Report)

R. Cook and P.R. Edwards

Royal Aircraft Establishment, Farnborough, UK, 19 pp (Apr 1983) Behaviour of Short Cracks in Airframe Components, Conf. Proc. Mtg. AGARD Struc. Matls. Panel (55th) Toronto, Canada, Sept 19-24, 1982
AD-P001 610

Key Words: Fatigue tests, Crack propagation

An experimental program was carried out to investigate short crack anomalies whereby short cracks propagate faster than long cracks at the same calculated stress intensity factor. This paper is the second to be issued on this program and contains all results to date. Fatigue tests were carried out on notched 2L65 aluminium alloy specimens under constant and variable amplitude loading.

84-541

Contact Fatigue Crack Initiation under Repeated Oblique Force

N. Yamashita and T. Mura

Dept. of Civil Engrg., Northwestern Univ., Evanston, IL 60201, Wear, 91 (2), pp 235-250 (Nov 1, 1983) 12 figs, 13 refs

Key Words: Fatigue life, Crack propagation

This study was planned and developed with the object of obtaining further information on the mechanism for the initiation of pitting cracks. An interesting feature observed during cyclic loading tests in which a one-directional tangential force was applied under stationary line contact is that two different types of cracks are observed at both edges of the contact region. A simple dislocation dipole model is proposed for this contact fatigue crack initiation.

84-542

Fracture Mechanics Analysis of Short Cracks at Loaded Holes

D.P. Rooke

Royal Aircraft Establishment, Farnborough, UK, 6 pp (Apr 1983) Behaviour of Short Cracks in Airframe Components, Conf. Proc. Mtg. AGARD Struc. Matls. Panel (55th) Toronto, Canada, Sept 19-24, 1982
AD-P001 607

Key Words: Crack propagation, Fatigue life

In a predominantly tensile field the time for a fatigue crack to grow a critical length is dominated by the time spent when the crack is short. Cracks frequently start in the vicinity of a stress concentrator such as a hole, and the stress intensity factor which controls crack growth-rate is largely determined by the local stress field. It is shown, by using a Green's function technique, that the presence of friction increases the stress intensity factor and hence increases the rate of growth of fatigue cracks which reduces the fatigue lifetime. The magnitude of these effects depends on the coefficient of friction and how it varies round the hole.

84-543

Threshold Range and Opening Stress Intensity Factor in Fatigue

H. Döker and G. Marci

DFVLR, The German Aerospace Res. Establishment, Inst. of Materials Res., Postfach 90 60 58, 5000 Koln 90, Fed. Rep. Germany, Intl. J. Fatigue, 5 (4), pp 187-191 (Oct 1983) 6 figs, 2 tables, 8 refs

Key Words: Fatigue life, Crack propagation

The fatigue threshold, ΔK_{th}, is strongly influenced by the stress-ratio; i.e., by the loading conditions. Results for a Ti6A14V alloy show that a ΔK exists for non-propagating fatigue cracks which is independent of loading conditions. This ΔK is called the fatigue tolerance range and is denoted by ΔK^T. The fatigue tolerance range corresponds to that of the ΔK_{th} during which the fatigue crack is open. Arguments that the fatigue tolerance range has to be explicitly incorporated in equations predicting fatigue crack growth rates are presented.

84-544

Numerical Simulation of Fatigue Crack Growth

D.K. Brown and M.J. Cowling

Univ. of Glasgow, Glasgow G12 8QQ, UK, Intl. J. Fatigue, 5 (4), pp 199-206 (Oct 1983) 10 figs, 12 refs

Key Words: Fatigue life, Simulation, Prediction techniques

A numerical simulation of fatigue crack growth which uses currently available crack tip stress and strain fields is described. The use of the model to illustrate the effects of stress ratio and environmental effects is described and the ability of the model to predict the onset of bursts of crack growth due to static failure mechanisms is demonstrated. The phenomenon of self-arresting cracks is also displayed. Material characteristics are included in the model and comparisons with experimental data are presented for a C-Mn steel used in the fabrication of offshore structures.

84-545

A Method for Improving the Performance of Fatigue Machines in Variable Amplitude Loading Tests

A. Lanciotti

Dept. of Aerospace Engrg., Univ. of Pisa, Via Diotisalvi, 2-1-56100, Pisa, Italy, Intl. J. Fatigue, 5 (4), pp 217-224 (Oct 1983) 12 figs, 2 refs

Key Words: Fatigue tests, Test equipment and instrumentation, Computer aided techniques

A method is described for improving the response of servohydraulic fatigue machines in variable amplitude loading tests driven by a process computer. The method allows a high working speed to be obtained while the output accuracy is maintained by means of suitable cycle-by-cycle input modification.

84-546

A Servohydraulic-Controlled Load Frame for SEM Fatigue Studies

D.W. Cameron and D.W. Hoeppner

Univ. of Toronto, Dept. of Mech. Engrg., Toronto, Ontario, Canada M5S 1A4, Intl. J. Fatigue, 5 (4), pp 225-229 (Oct 1983) 10 figs, 6 refs

Key Words: Fatigue tests, Test equipment and instrumentation

The design of a servohydraulic-controlled load frame for real-time scanning electron microscope observations of cyclically loaded specimens is discussed. Details of a machine having a 1.3 kN capacity frame, control electronics and a video recording system are given. The equipment has been used to study fatigue in a copper single crystal, RR 58 aluminium alloy and IMI 829.

84-547

"Flaw Matrix" and Its Application to Some Ceramics

N. Kamiya and O. Kamigaito

Toyota Central Res. and Dev. Labs., 41-1 Aza Yokomichi, Oaza Nagakute, Nagakute-cho, Aichi-gun, Aichi-ken, 480-11, Japan, Intl. J. Fatigue, 5 (4), pp 231-238 (Oct 1983) 12 figs, 13 refs

Key Words: Fatigue tests, Testing techniques, Ceramics

An improved method for the prediction of fatigue life and/or failure strength of ceramics is proposed, which is especially useful for ceramics whose failure strength does not follow Weibull statistics and for the prediction of failures with a low probability. It is shown that various types of failure data such as fatigue life, failure strength and short time failure strength are all useful for the prediction of failures.

84-548

The Fatigue Life and Plastic Deformation Character of Copper at Low Temperatures

L.F. Yakovenko and N.M. Grinberg

Physico-Technical Inst. of Low Temperatures, Ukrainian Academy of Sciences, 47 Lenin Avenue, Kharkov, 310164, USSR, Intl. J. Fatigue, 5 (4), pp 239-243 (Oct 1983) 5 figs, 1 table, 15 refs

Key Words: Fatigue life, Temperature effects

The fatigue life of polycrystalline copper has been determined in the temperature range 293 K - 12 K in vacuum at constant strain amplitude and the plastic deformation of the samples followed. The fatigue life is found to increase with decreasing temperature down to 100 K; it then decreases as the temperature is further reduced. This behavior is explained in terms of the change in plastic deformation of the sample with temperature.

84-549

Advanced Fatigue Damage Development in Graphite Epoxy Laminates

R.D. Jamison and K.L. Reifsnider

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, Rept. No. AFWAL-TR-82-3103, 234 pp (Dec 1982)

AD-A130 190

Key Words: Layered materials, Fatigue tests

Results of an experimental investigation of damage development in T300/5208 graphite epoxy laminates subjected to tension-tension cyclic loading are reported. The concept of laminate stiffness reduction as a damage analogue is shown to be a valuable means of test control and damage interpretation. The relationship between stiffness and number of cycles is shown to be unique for each laminate type studied, each possessing three distinct stages, but markedly different among the laminate types.

84-550

Compression and Compression Fatigue Testing of Composite Laminates

T.R. Porter

Boeing Military Airplane Development Organization, Boeing Aerospace Co., Seattle, WA, Rept. No. D180-27619-1, NASA-CR-168023, 135 pp (1982)

N83-26928

Key Words: Composite structures, Layered materials, Fatigue tests, Crack propagation

The effects of moisture and temperature on the fatigue and fracture response of composite laminates under compression loads were investigated. The structural laminates studied were an intermediate stiffness graphite-epoxy composite. Full and half penetration slits and impact delaminations were the defects examined.

ELASTICITY AND PLASTICITY

84-551

Damage Tolerance Evaluation of Structures with Small Cracks

L. Schwarmann

Vereinigte Flugtechnische Werke GmbH, Bremen, Germany, 6 pp (Apr 1983) Behaviour of Short Cracks in Airframe Components, Conf. Proc. Mtg. AGARD Struc. Matls. Panel (55th), Toronto, Canada, Sept 19-24, 1982, AD-A131 159, pp 7-1 - 7-6

AD-P001 606

Key Words: Crack propagation

This paper deals with the analytical determination of the linear-elastic stress intensity factor for structures with small cracks. Two different cases are considered. Results obtained from analyses are compared with corresponding test results.

84-552

Effects of Compressive Overloads on the Threshold Stress Intensity for Short Cracks

P. Au, T.H. Topper, and M.L. El Haddad

Waterloo Univ., Ontario, Canda, 7 pp (Apr 1983) Behaviour of Short Cracks in Airframe Components, Conf. Proc. Mtg. AGARD Struc. Matls. Panel (55th), Toronto, Canada, Sept 19-24, 1982

AD-P001 609

Key Words: Crack propagation

Crack propagation specimens of an aluminum alloy are subjected to continuous and periodic cycles having compressive stresses. Results indicate that for a tension compression load cycle crack growth in the near threshold regime is controlled by the tensile peak stress intensity and the compressive peak stress. Compressive loading significantly reduces the threshold intensity and increases crack growth rate.

WAVE PROPAGATION

84-553

Scatter of Elastic Waves by a Thin Flat Elliptical Inhomogeneity

L.S. Fu

Dept. of Engrg. Mechanics, Ohio State Univ., Columbus, OH, Rept. No. NASA-CR-3705, 20 pp (July 1983)

N83-29725

Key Words: Elastic waves, Wave scattering

Elastodynamic fields of a single, flat, elliptical inhomogeneity embedded in an infinite elastic medium subjected to plane time harmonic waves are studied. Scattered displacement amplitudes and stress intensities are obtained in series form for an incident wave in an arbitrary direction. The cases of a penny-shaped crack and an elliptical crack are given as examples.

84-554

Workshop on Research Techniques in Wave Propagation and Scattering Held on 18-21 October 1982

V.V. Varadan and V.K. Varadan

Dept. of Engrg. Mechanics, Ohio State Univ., Columbus, OH, 5 pp (May 12, 1983)

AD-A130 270

Key Words: Wave propagation, Wave scattering

The general lectures given at this workshop were of an expository nature on fundamental concepts and basic analytical/numerical techniques for the solution of wave scattering and propagation problems. The written version of many of these lectures will appear in a four volume Handbook on Acoustic, Electromagnetic and Elastic Wave Scattering to be published by North Holland as a separate project.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

(Also see No. 534)

84-555

Substructuring and Modal Synthesis for Damped Systems

L. Wu and R. Greif

Dept. of Mech. Engrg., Tufts Univ., Medford, MA 02155, J. Sound Vib., 90 (3), pp 407-422 (Oct 8, 1983) 13 tables, 10 refs

Key Words: Damped structures, Substructuring methods, Modal synthesis

A new approach to complex mode synthesis for damped systems is presented. The technique involves using two successive transformations of the equations written in first order, state space form. The transformations are applied to each subsystem, with consecutive use being made of free interface undamped modes in the existing physical co-ordinates followed by fixed interface damped modes in the generalized co-ordinates. An advantage of the technique is that it can be applied to systems or subsystems possessing rigid body motion.

84-556

Frequency Domain Reflectometer for Quartz Resonator Investigations

C.S. Stone and O.J. Baltzer

Tracor, Inc., Austin, TX, 6 pp (1982) Proc. of Symp. on Frequency Control (36th Annual), June 2-4, 1982, Philadelphia, PA

AD-P001 540

Key Words: Resonators, Quartz crystals, Frequency domain method

This paper presents the concept and operating principles of a phase modulated, frequency-domain reflectometer system for accurate and precise measurements of the resonant frequency characteristics of quartz crystals. The reflectometer method enables the crystal resonator under test to be remotely located in an environmental test chamber; furthermore, the system permits simultaneous, independent frequency measurements of the various resonant modes that can occur in any given crystal.

84-557

Fast Modal Response Method for Structures

Y.T. Leung

Dept. of Civil Engrg., Univ. of Hong Kong, Hong Kong, Intl. J. Numer. Methods Engrg., 19 (10), pp 1435-1451 (Oct 1983) 1 fig, 11 tables, 5 refs

Key Words: *Modal analysis*

Regardless of their simplicity, all structures have an infinite number of degrees-of-freedom (d.o.f.) when subjected to

dynamic loading. The usual finite element method reduces the infinite d.o.f. system to a model with a limited d.o.f. while capturing the significant physical behavior. The modal analysis reduces the number of d.o.f. further to a limited number of modal co-ordinates. However, accurate results comparable to the original finite element model may not be possible unless higher modes are included. The present paper is to recommend a response analysis which makes use of both the natural modes and the mass and stiffness matrices of the system to improve the convergence with respect to the number of modes.

84-558

Determination of Mechanical Impedance through Strain Measurement on an Impacted Slender Rod

L. Lagerkvist and K.G. Sundin

Dept. of Mech. Engrg., Lulea Univ., Sweden, Rept. No. TULEA-1982-33-T, ISSN-0349-3571, 153 pp (1982)

N83-27274

Key Words: Mechanical impedance, Measuring instruments, Computer aided techniques, Computer programs

An impedance gage based on measurement of strains at two cross sections of a slender rod is studied. The gage rod is in contact with the object at one end and is impacted at the other. The impedance is evaluated from the two strain signals by a two channel fast Fourier transformation analyzer and a desktop computer. Gage prototypes with cylindrical and conical geometries were tested in the frequency range 50 Hz to 5 kHz for cylindrical objects with known theoretical point impedances.

DYNAMIC TESTS

84-559

Equivalence Techniques for Vibration Testing

H.S. Blanks

School of Electrical Engrg. and Computer Science, Univ. of New South Wales, P.O. Box 1, Kensington, NSW, 2033, Australia, Shock Vib. Dig., 15 (8), pp 3-10 (Aug 1983) 52 refs

Key Words: Vibration tests, Equivalence principle, Reviews

This survey covers the literature from 1980 to 1982 for producing, evaluating, and utilizing equivalence techniques in field and laboratory vibration testing. Different forms of laboratory testing are also surveyed; modal testing is not covered. Screening by vibration exposure is included although its purpose is not the reproduction of field vibration.

84-560

Blast and Shock Field Test Management

M.L. Noble

Air Force Contract Management Div., Los Angeles, CA, Rept. No. AFCMD/82-018, 29 pp (June 29, 1983)

AD-A130 323

Key Words: Missiles, Shock tests, Blast response, Shock response

Matrix management functions as the principal field test management technique. A test integrator (test director) is the responsible agent in the management of any blast and shock field test program. The central thrust of the discussion is to present the Air Force Weapons Laboratory, Civil Engineering Division's (AFWAL/NTE) integrative (matrix) structure with its test planning and operating elements.

84-561

Instrumentation for Protective Structures Testing

J.V. Quintana

Ballistic Missile Office, Norton AFB, CA, Rept. No. BMO-82-062, 28 pp (June 29, 1983)

AD-A130 321

Key Words: Missile silos, Protective shelters, Test equipment and instrumentation

Selected stress and motion parameters associated with test input stimulus, free-field response, and specimen structure responses are identified as measurands in simulation testing of Air Force protective structures. For each measurand, the corresponding sensor and sensing technique used by the AF is illustrated and briefly described. Observed performance is noted and other factors reveal implementation guidelines.

DIAGNOSTICS

84-562

Overall Measurement of Vibration Levels, Percent Bandwidth Analysis and FFT Digital Analysis Com-

pleting Diagnosis of Defects in Compressor Group Installed in Caraiba Metals

L.X. Nepomuceno, J.J. Spindola, and A. Lenzi
Laboratorio de Acustica e Sonica, Sao Paulo, Brazil,
Rept. No. REPT-1503/83, 74 pp (May 1983)
N83-28492
(In Portuguese)

Key Words: Diagnostic techniques, Compressors

The procedures, instruments, and the results of a complete vibration analysis (overall levels, percent bandwidth analysis, Digital FFT analysis in the three axles) of a set of electric motor/hydraulic coupler/gear multiplier/compressor are described.

MONITORING

84-563

Rotating Machinery: Monitoring and Fault Diagnosis

R.G. Smiley
Entek Scientific Corp., Cincinnati, OH, S/V, Sound Vib., 15 (9), pp 26-28 (Sept 1983) 7 figs, 2 refs

Key Words: Diagnostic techniques, Monitoring techniques, Rotating machinery

Low-cost, high-performance transducers, data acquisition, and computing equipment available in today's market bring automatic machinery health monitoring and fault diagnosis capability within reach of virtually every machinery operator. In this article some of the current trends in monitoring and fault diagnosis in rotating machinery are reviewed. A general approach to evaluation of the economics of monitoring is also presented.

84-564

FATSYS, a Computer Controlled System for Fatigue Crack Growth Data Collection Using an Amsler Vibrophore

J.R. Griffiths
MRDE, Ashby Rd., Stanhope Bretby, Burton on Trent, Staffs, DE15 0QD, UK, Intl. J. Fatigue, 5 (4), pp 193-197 (Oct 1983) 5 figs, 2 tables, 2 refs

Key Words: Monitoring techniques, Fatigue life, Crack propagation

A system of hardware and software developed for collecting fatigue crack growth data from an Amsler Vibrophore fatigue machine is described. The system allows testing at constant, increasing and decreasing stress intensity factor ranges, and it generally complies with the proposed ASTM standards on fatigue crack growth testing. The system has proven to be extremely beneficial particularly for work at growth rates approaching threshold, where manual methods are tedious and time consuming.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

84-565

Eigenanalysis of the Rigid Body Motion Effect on Elastic Systems

A. Maher and A.L. Schlack
Dept. of Engrg. Mechanics, Univ. of Wisconsin, Madison, WI, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 105 (3), pp 461-466 (Oct 1983) 2 figs, 3 tables, 14 refs

Key Words: Eigenvalue problems, Beams, Rayleigh-Ritz method

The influence of rigid body motion on the behaviour of a vibrating elastic system is treated by the development of a difference eigenvalue problem. The maximum possible changes in eigenfrequencies due to removal of constraints are obtained by the employment of the bound approach. As an application to a structural system the Rayleigh-Ritz procedure is employed for constructing the difference eigenvalue problem. Discussion of the use of the method for various types of engineering problems is outlined.

84-566

A Dynamic Substructuring Method for Elastoimpact Stress Analysis Using Finite Element Method

N. Asano
Tamagawa Univ., Machida, Tokyo, 194, Japan, Bull. JSME, 26 (218), pp 1308-1314 (Aug 1983) 8 figs, 3 tables, 13 refs

Key Words: Substructuring methods, Finite element technique

A dynamic substructuring method is presented for the efficient calculation of the finite element method. The method is mainly composed of the Runge-Kutta-Gill method, the lumped mass matrix, and the substructuring stiffness matrices. To verify the validity of the method, it is applied to the longitudinal elastoimpact analysis of two-dimensional elastic rods having a uniform cross section and a variable one in collision with a rigid wall. The calculated values of the substructuring models agree precisely with those of the whole rod models.

84-567
Incorporation of Lagrangian Multipliers into an Algorithm for Finding Exact Natural Frequencies or Critical Buckling Loads
F.W. Williams and M.S. Anderson
Univ. of Wales, Inst. of Science and Tech., Cardiff CF1 3EU, Wales, Intl. J. Mech. Sci., 25 (8), pp 579-584 (1983) 1 fig, 8 refs

Key Words: Algorithms, Natural frequencies, Critical loads, Eigenvalue problems

An existing algorithm enables natural frequencies or critical load factors to be found with certainty when exact stiffness matrices are used. This algorithm is extended to permit Lagrangian multipliers to be used to couple the exact stiffness matrices of component structures to represent connections between the structures. The new algorithm also permits coupling of the stiffness matrices for different assumed wavelengths of sinusoidal response of a given structure with the stiffness matrices of other structures to satisfy required constraint conditions.

84-568
Some Aspects of Fluid-Structure Coupling (LMFBR)
R.F. Kulak
Argonne Natl. Lab., Argonne, IL, Rept. No. CONF-820601-30, 36 pp (1982) (ASME Pressure Vessel Piping Conf., Orlando, FL, June 27, 1982)
DE 83010575

Key Words: Interaction: structure-fluid

This paper primarily discusses the formulation used in an algorithm that couples three-dimensional hydrodynamic and structural domains. The fluid domain is governed by the Navier-Stokes equations, and the structural domain is governed by the equations of nonlinear structural dynamics. Both the fluid and structure are discretized using finite elements.

MODELING TECHNIQUES

(See No. 459)

PARAMETER IDENTIFICATION

(Also see No. 454)

84-569
Aerodynamic Model Identification from Dynamic Flight Test Data and Wind Tunnel Experiments
J.A. Mulder, J.G. Denhollander, and H. Binkhorst
Dept. of Aerospace Engrg., Technische Hogeschool, Delft, The Netherlands, Rept. No. VTH-LR-361, 23 pp (Oct 1982)
N83-27967

Key Words: Parameter identification technique, Wind tunnel testing, Flight vehicles

The identification of multi-input, single-output linear static models from flight test data is discussed. Models based on least squares are considered. Wind tunnel scale model and flight test data on a propeller slip-stream are compared.

COMPUTER PROGRAMS

84-570
Examples in the Use of the Finite Element Library: Forced Vibration of an Elastic Solid Solution by Modal Superposition
C. Greenough and K. Robinson
Rutherford Appleton Lab., Science and Engrg., Res. Council, Chilton, England, Rept. No. RL-82-065, 27 pp (1982)
PB83-242982

Key Words: Computer programs, Finite element technique, Forced vibration, Modal superposition method

The Finite Element Library at RAL is in two levels: one consists of subroutines to perform the basic steps required

in finite element analysis and the other comprises example programs. The illustrated example calculates the displacement of a two dimensional rectangular solid acted upon by a time dependent force. The theory and solution are outlined and the program described in its main sections of: data input and variable initialization; element and system matrix assembly; and solution for displacements.

84-571

Computer Program DYNFIN for the Calculation of the Dynamic Behavior of Mechanical Structures (Programmsystem DYNFIN zur Berechnung des dynamischen Verhaltens mechanischer Strukturen)

Konstruktion, 35 (10), p 410 (Oct 1983)
(In German)

Key Words: Computer programs, Finite element technique

A finite element computer program is described which was developed specifically for dynamic problems. Its possibilities include real and complex (i.e., with or without damping considerations) eigenvalue and response analysis in frequency or time domain. The program is written in Fortran IV; length of the program is about 3000 instructions which are subdivided into several programs. It can be applied in machine design and in all fields in which the dynamic behavior of mechanical systems has to be determined. It is available from the editorial staff of Konstruktion, Springer Vg., Otto-Suhr Allee 26-28, 1000 Berlin 10, Germany.

84-572

Use of Simplified Input for BLAST Energy Analysis

D. Herron, J. Eidsmore, R. O'Brien, and D. Leverenz
Construction Engrg. Res. Lab. (Army), Champaign, IL, Rept. No. CERL-TR-E-185, 114 pp (May 1983)
AD-A131 261

Key Words: Computer programs, Blast-resistant structures

This study demonstrated that a simplified input to the Building Loads Analysis and System Thermodynamics (BLAST) energy analysis computer program will generate results accurate enough for designers to use during the early stages of the Military Construction, Army (MCA) facility design process.

84-573

Buckling and Vibration of any Prismatic Assembly of Shear and Compression Loaded Anisotropic Plates with an Arbitrary Supporting Structure

M.S. Anderson, F.W. Williams, and C.J. Wright
Structural Concepts Branch, NASA Langley Res. Ctr., Hampton, VA 23665, Intl. J. Mech. Sci., 25 (8), pp 585-596 (1983) 7 figs, 3 tables, 7 refs

Key Words: Computer programs, Natural frequencies, Plates, Anisotropy

The VIPASA computer program accurately treats buckling and vibration of prismatic plate assemblies with a response that varies sinusoidally in the longitudinal direction. In-plane shear loading of component plates produces skewed mode shapes that do not conform to desired support conditions, and this has placed a limitation on the general applicability of VIPASA. This problem is overcome in the present paper by coupling the VIPASA stiffness matrices for different wavelength responses through the method of Lagrangian multipliers. Supports at arbitrary locations, including support provided by an elastic structure, are included in the theory.

84-574

Gust Response of a Light, Single-Engined, High-Wing Aircraft

C.J. Ludowyk
Aeronautical Res. Labs., Melbourne, Australia, Rept. No. ARL/AERO-TM-345, 49 pp (Jan 1983)
AD-A131 033

Key Words: Computer programs, Aircraft, Wind-induced excitation

A recently developed Fortran program for calculating rigid-aircraft gust response has been applied to obtain longitudinal and lateral transfer functions and output response spectra for a general aviation, high-wing aircraft.

84-575

Computerized Mathematical Eigenvalue Models. 1970 - July 1983 (Citations from the NTIS Data Base)

NTIS, Springfield, VA, 194 pp (July 1983)
PB83-869669

Key Words: Eigenvalue problems, Computer programs, Bibliographies

This bibliography contains 170 citations concerning various computer programs and techniques used to solve mathematical problems too large and/or complex for manual manipulation. Most of the citations are slanted toward the solution of sophisticated matrices as they relate to the problems of structural design, stability, dynamics and holding. Computerized theoretical formulas and equations applicable to general areas of engineering are also presented.

GENERAL TOPICS

TUTORIALS AND REVIEWS

(See Nos. 453, 533)

BIBLIOGRAPHIES

84-576

Vibrational Analysis in Aerodynamics. 1970 - August, 1983 (Citations from the NTIS Data Base)

NTIS, Springfield, VA, 259 pp (Aug 1983)

PB83-870360

Key Words: Helicopters, Flight vehicles, Vibration analysis, Bibliographies

This bibliography contains 200 citations concerning excitation and analysis techniques for flight flutter tests. Although fixed-wing aircraft, space flight vehicles, VTOL and V/STOL vehicles are included, helicopter generated vibration analysis is emphasized in this bibliography.

84-577

Acoustic Intensity Measurement. 1975 - August, 1983 (Citations from the International Information Service for the Physics and Engineering Communities Data Base)

NTIS, Springfield, VA, 233 pp (Aug 1983)

PB83-870121

Key Words: Acoustic intensity method, Measurement techniques, Measuring instruments, Bibliographies

This bibliography contains 236 citations concerning techniques and devices for the measurement of acoustic intensity from a variety of sources. Topics include automated measuring systems, calibration, transient noise sources, errors in acoustic intensity measurements, source characterization, and finite difference approximation errors.

84-578

Vibrational Analysis in Fluids. 1972 - July, 1983 (Citations from the International Aerospace Abstracts Data Base)

NTIS, Springfield, VA, 136 pp (July 1983)

PB83-868984

Key Words: Vibration analysis, Bibliographies

This bibliography contains 125 citations concerning analyses of vibrational, fatigue, stress, and mechanical responses of fluid systems through a range of applications. Experimental studies relative to various shapes and mechanisms working within fluid systems applicable to numerous fields are examined. Specific data and procedures include applications in structural mechanics, aerodynamics, hydrodynamics, and hydraulics.

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pp 21-23, 4 figs (in German)

E. Anton
Active Control of Parametrically Excited Rotor Systems
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H. Bardowicks
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R. Bogacz and P. Dunaj
On Dynamics of Continuous Systems Subjected to Moving Load
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T. Tarnai, M. Kurutz, and G. Popper
Numerical Solution of Eigenvalue Problems with Eigenvalue Parameter in the Boundary Conditions by Lambda Matrices
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D. Teichmann
Dynamics and Stability of Open Shells
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Tran Van Nhung
An Application of Lyapunov's Exponent Method to the Moment Stability Problem
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H. Troger
The Application of the Ritz-Galerkin Method in Branching Problems
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A. Truckenbrodt
Vibration of Thin-Walled Cylindrical Rotors
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H. Ulbrich and U. Kleemann
Investigation of the Instabilities of Actively Controlled Rotor with an Elastic Structure
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W. De Wilde and B. Narmon
Probabilistic Dynamical Analysis of a Marine Riser
pp 122-124, 2 figs, 7 refs (in English)

CALENDAR

APRIL 1984

9-12 Design Engineering Conference and Show [ASME] Chicago, IL *(ASME Hqs.)*

9-13 2nd International Conference on Recent Advances in Structural Dynamics [Institute of Sound and Vibration Research] Southampton, England *(Dr. Maurice Petyt, Institute of Sound and Vibration Research, The University of Southampton, S09 5NH, England - (0703) 559122, Ext. 2297)*

30-May 3 Institute of Environmental Sciences' 30th Annual Technical Meeting [IES] Orlando, FL *(IES, 940 E. Northwest Highway, Mt. Prospect, IL 60056 - (312) 255-1561)*

MAY 1984

1-3 Mechanical Failures Prevention Group 38th Symposium [National Bureau of Standards, Washington, DC] Gaithersburg, MD *(Dr. J.G. Early, Metallurgy Div., Room A153, Bldg. 223, National Bureau of Standards, Washington, DC 20234)*

7-10 30th International Instrumentation Symposium [Instrument Society of America] Denver, CO *(Robert Jarvis, Grumman Aerospace Corp., Mail Stop T01-05, Bethpage, NY 11714)*

7-11 Acoustical Society of America, Spring Meeting [ASA] Norfolk, VA *(ASA Hqs.)*

10-11 12th Southeastern Conference on Theoretical and Applied Mechanics [Auburn University] Pine Mountain, GA *(J. Fred O'Brien, Director, Engineering Extension Service, Auburn University, AL 36849 - (205) 826-4370)*

JUNE 1984

3-7 29th International Gas Turbine Conference and Exhibit [ASME] Amsterdam, The Netherlands *(ASME Hqs.)*

26-28 Machinery Vibration Monitoring and Analysis Meeting [Vibration Institute] New Orleans, LA *(Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)*

JULY 1984

21-28 8th World Conference on Earthquake Engineering [Earthquake Engineering Research Institute] San Francisco, CA *(EERI-8WCEE, 2620 Telegraph Avenue, Berkeley, CA 94704)*

AUGUST 1984

6-9 West Coast International Meeting [SAE] San Diego, CA *(SAE Hqs.)*

19-25 XVIth International Congress on Theoretical and Applied Mechanics [International Union of Theoretical and Applied Mechanics] Lyngby, Denmark *(Prof. Frithiof Niordson, President, or Dr. Niels Olhoff, Executive Secretary, ICTAM, Technical University of Denmark, Bldg. 404, Dk-2800 Lyngby, Denmark)*

SEPTEMBER 1984

9-11 Petroleum Workshop and Conference [ASME] San Antonio, TX *(ASME Hqs.)*

11-13 Third International Conference on Vibrations in Rotating Machinery [Institution of Mechanical Engineers] University of York, UK *(IMechE Hqs.)*

30-Oct 4 Power Generation Conference [ASME] Toronto, Ontario, Canada *(ASME Hqs.)*

OCTOBER 1984

7-11 10th Design Automation Conference and 18th Mechanisms Conference [ASME] Cambridge, MA *(Prof. Panos Papalambros, Mechanical Engineering and Applied Mechanics, The Univeristy of Michigan, Ann Arbor, MI 48109 - (313) 763-1046)*

8-12 Acoustical Society of America, Fall Meeting [ASA] Minneapolis, MN *(ASA Hqs.)*

9-11 13th Space Simulation Conference [IES, AIAA, ASTM, and NASA] Orlando, FL *(Institute of Environmental Sciences, 940 E. Northwest Hwy., Mt. Prospect, IL 60056 - (312) 255-1561)*

15-18 Aerospace Congress and Exposition [SAE] Long Beach, CA *(SAE Hqs.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics
1633 Broadway
New York, NY 10019

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASLE: American Society of Lubrication Engineers
838 Busse Highway
Park Ridge, IL 60068

ASME: American Society of Mechanical Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

ICF: International Congress on Fracture
Tohoku University
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IMechE: Institution of Mechanical Engineers
1 Birdcage Walk, Westminster,
London SW1, UK

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
67 Alexander Dr.
Research Triangle Park, NC 27709

SAE: Society of Automotive Engineers
400 Commonwealth Dr.
Warrendale, PA 15096

SEE: Society of Environmental Engineers
Owles Hall, Buntingford, Hertz.
SG9 9PL, England

SESA: Society for Experimental Stress Analysis
14 Fairfield Dr.
Brookfield Center, CT 06805

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Laboratory
Code 5804
Washington, D.C. 20375

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